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**Awazu et al.**

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(45) **Date of Patent:** **\*Aug. 15, 2023**

(54) **IMAGE SHAKE CORRECTION DEVICE AND IMAGING DEVICE**

(58) **Field of Classification Search**  
CPC ..... H04N 23/54; H04N 23/68; H04N 23/685; H04N 23/687

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(Continued)

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(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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This patent is subject to a terminal disclaimer.

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*Primary Examiner* — Anthony J Daniels

(63) Continuation of application No. 17/116,873, filed on Dec. 9, 2020, now Pat. No. 11,402,653, which is a (Continued)

(74) *Attorney, Agent, or Firm* — Studebaker & Brackett PC

(30) **Foreign Application Priority Data**

Sep. 27, 2017 (JP) ..... 2017-186876

(57) **ABSTRACT**

An image shake correction device includes: a movable member; an imager that is fixed to the movable member; a support member that supports the movable member to be movable; and two movement restrictors that restrict a movement range of the movable member, each of the two movement restrictors includes a recess portion or a through-hole and an insertion member as defined herein, a shape of the recess portion or the through-hole is as defined herein, and a second diagonal line overlaps an extension line of a first diagonal line and the center of the light receiving surface overlaps a line connecting the first diagonal line and the second diagonal line as defined herein.

(51) **Int. Cl.**

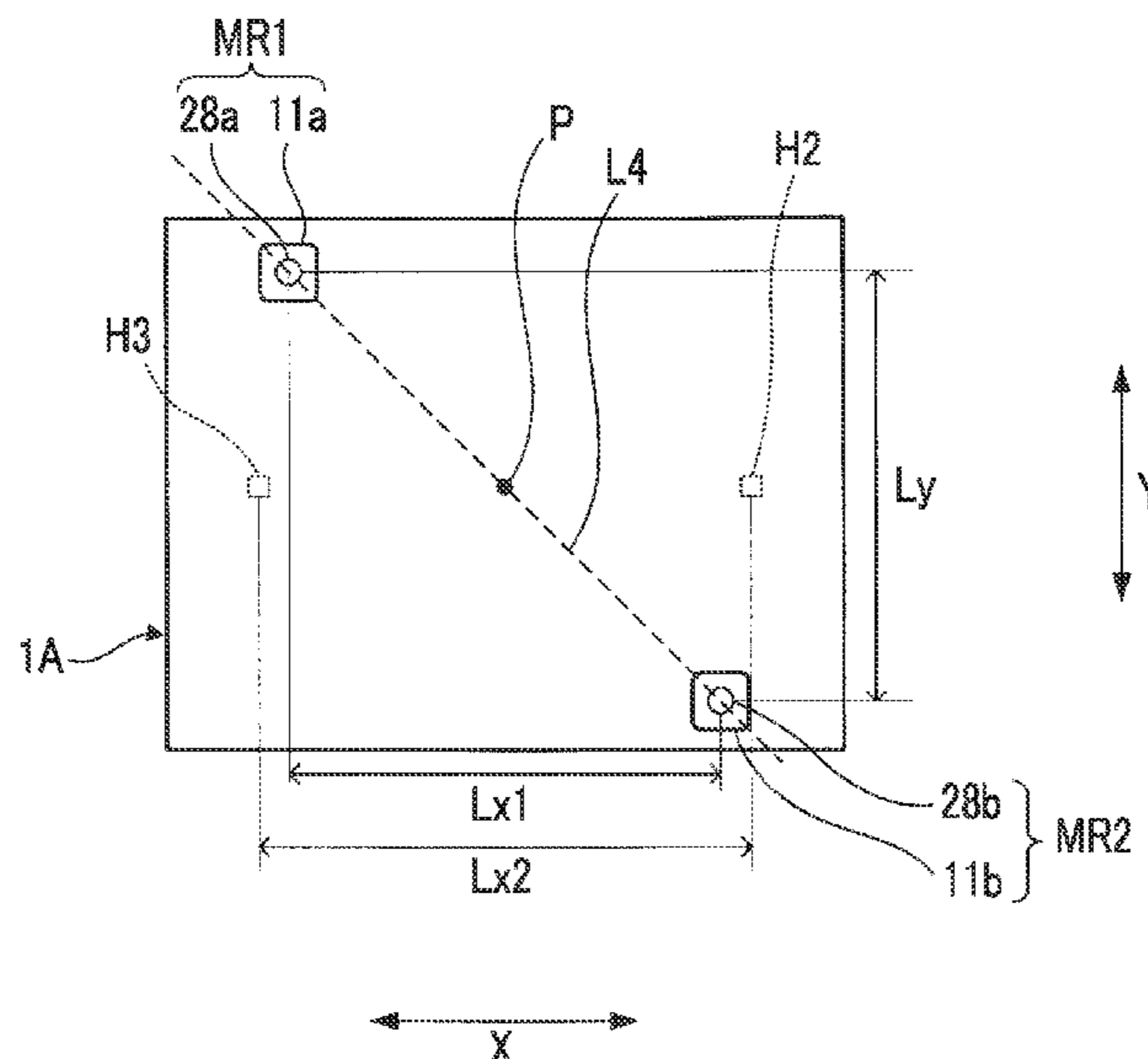
**H04N 5/225** (2006.01)  
**G02B 27/64** (2006.01)

(Continued)

**20 Claims, 23 Drawing Sheets**

(52) **U.S. Cl.**

CPC ..... **G02B 27/646** (2013.01); **G03B 5/00** (2013.01); **H04N 23/687** (2023.01)



**Related U.S. Application Data**

continuation of application No. 16/831,690, filed on Mar. 26, 2020, now Pat. No. 10,884,259, which is a continuation of application No. PCT/JP2018/035901, filed on Sep. 27, 2018.

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(51) **Int. Cl.**

**G03B 5/00** (2021.01)  
**H04N 23/68** (2023.01)

(58) **Field of Classification Search**

USPC ..... 348/208.99, 208.4, 208.7, 373  
See application file for complete search history.

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FIG. 1

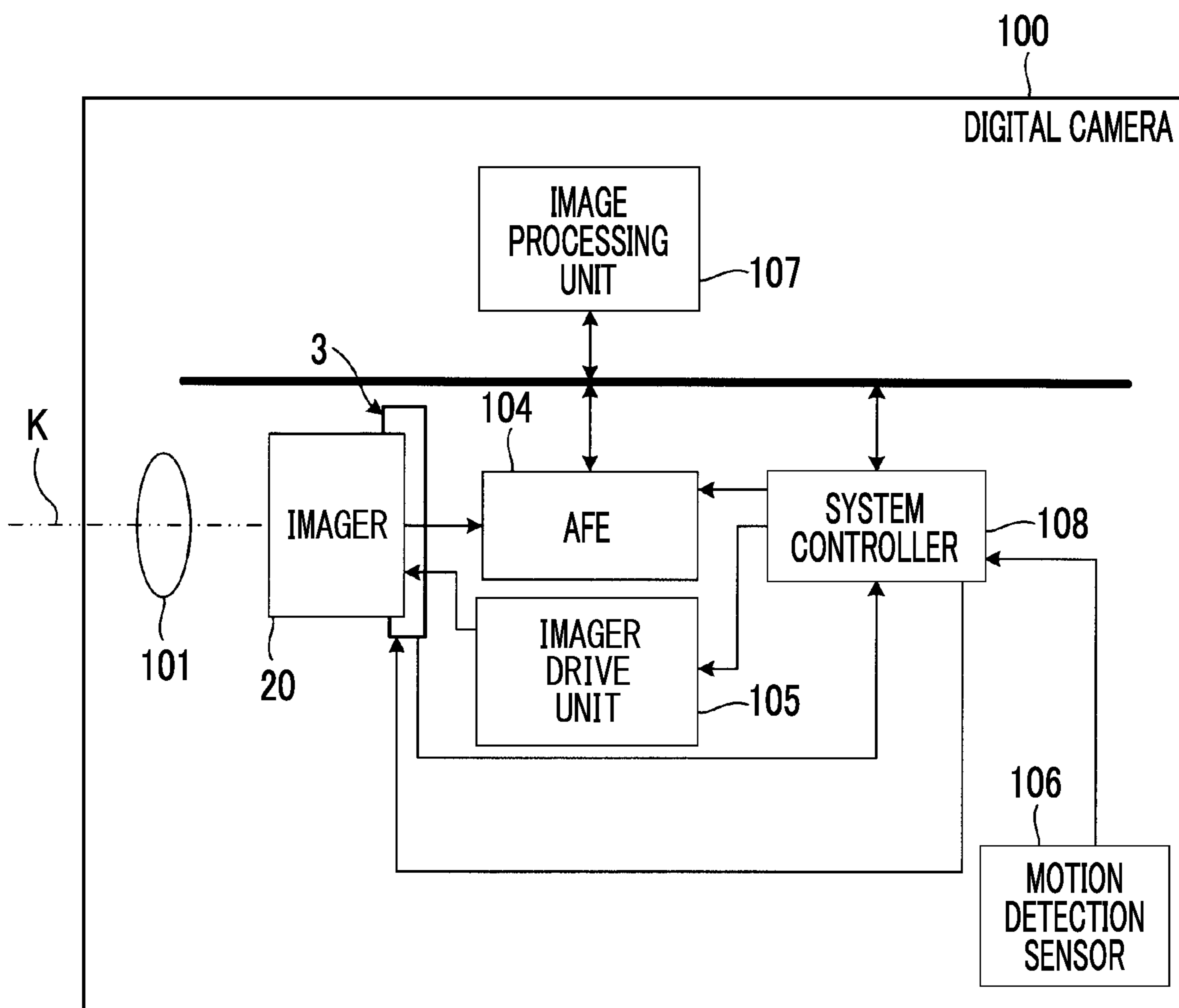


FIG. 2

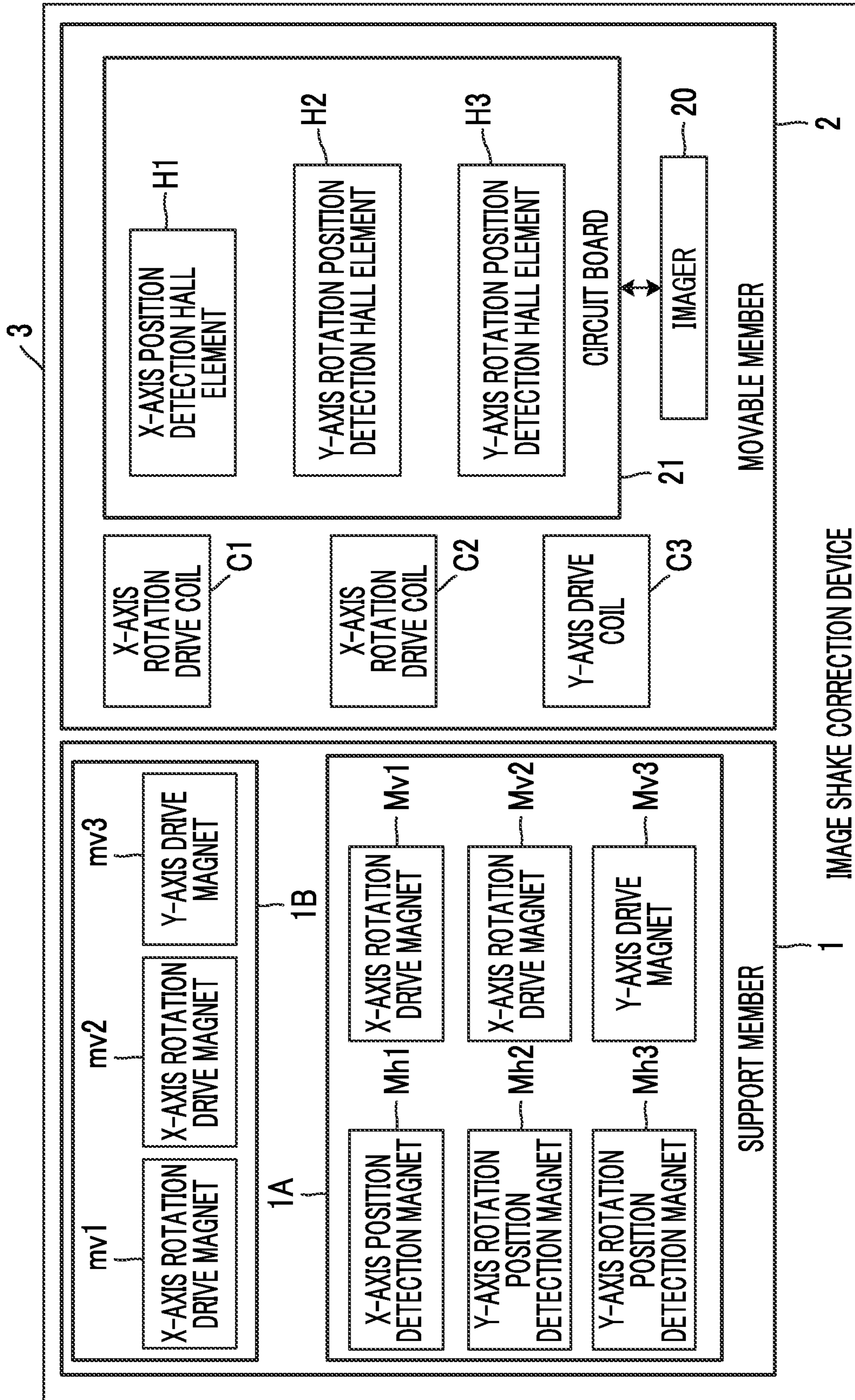
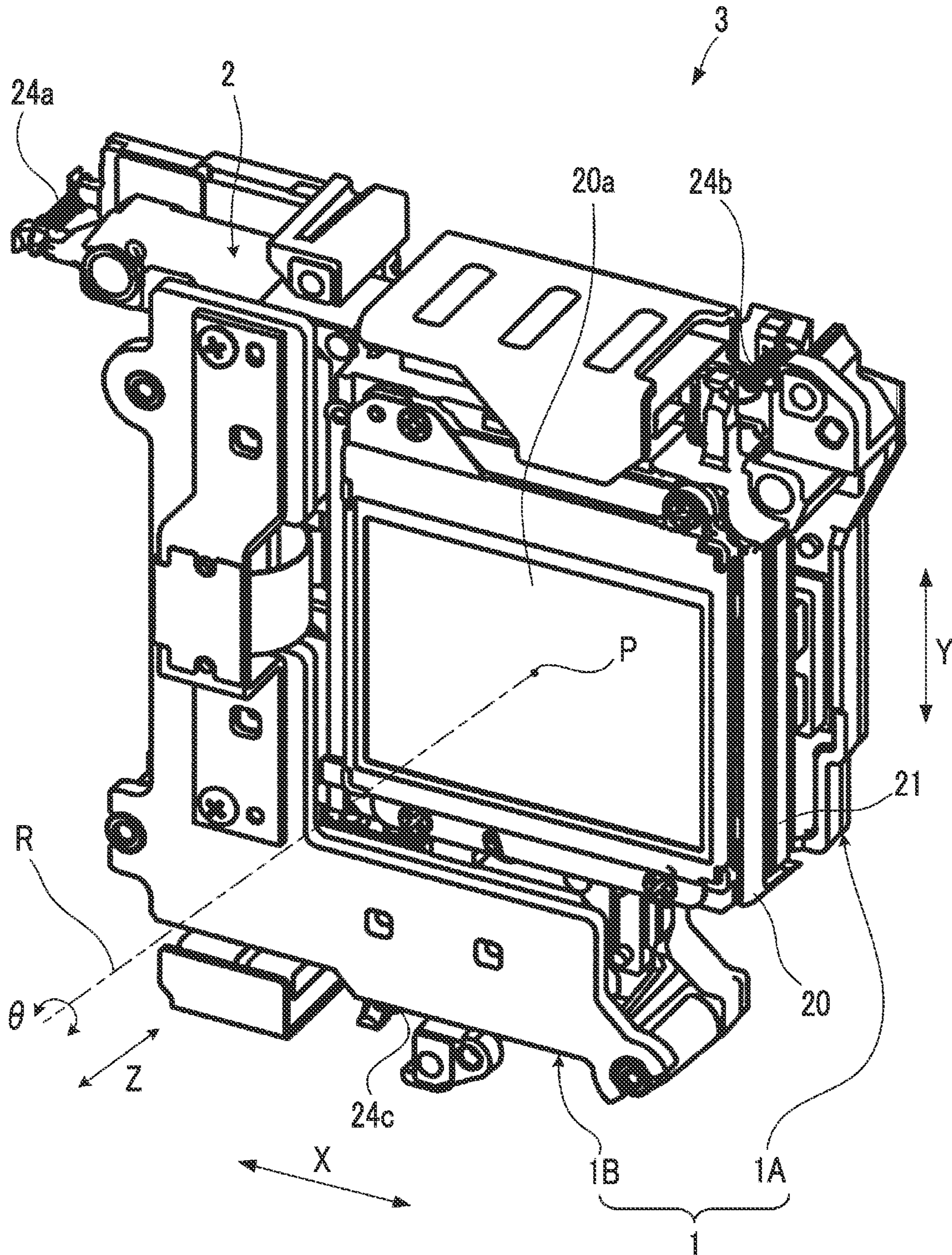
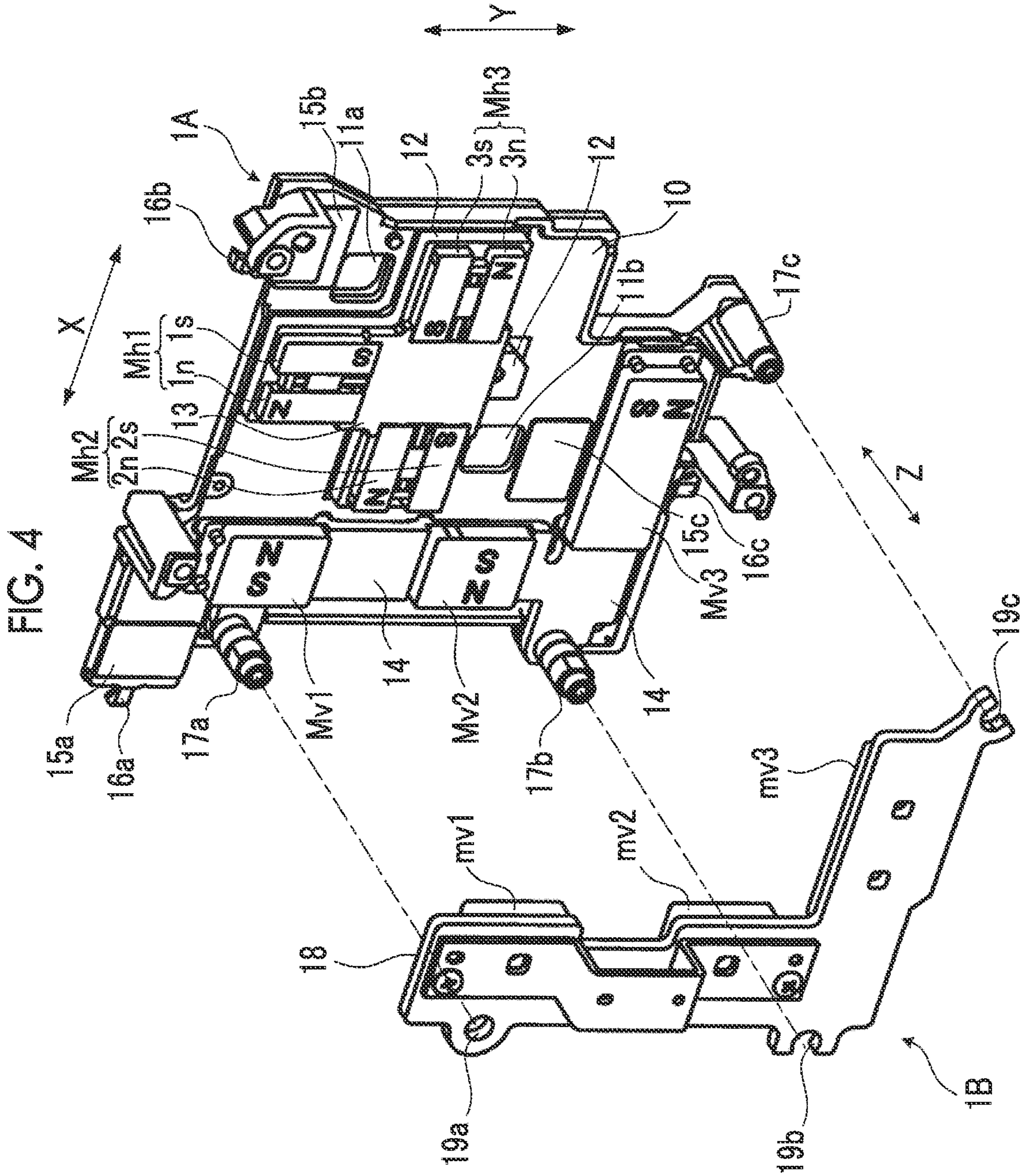


FIG. 3





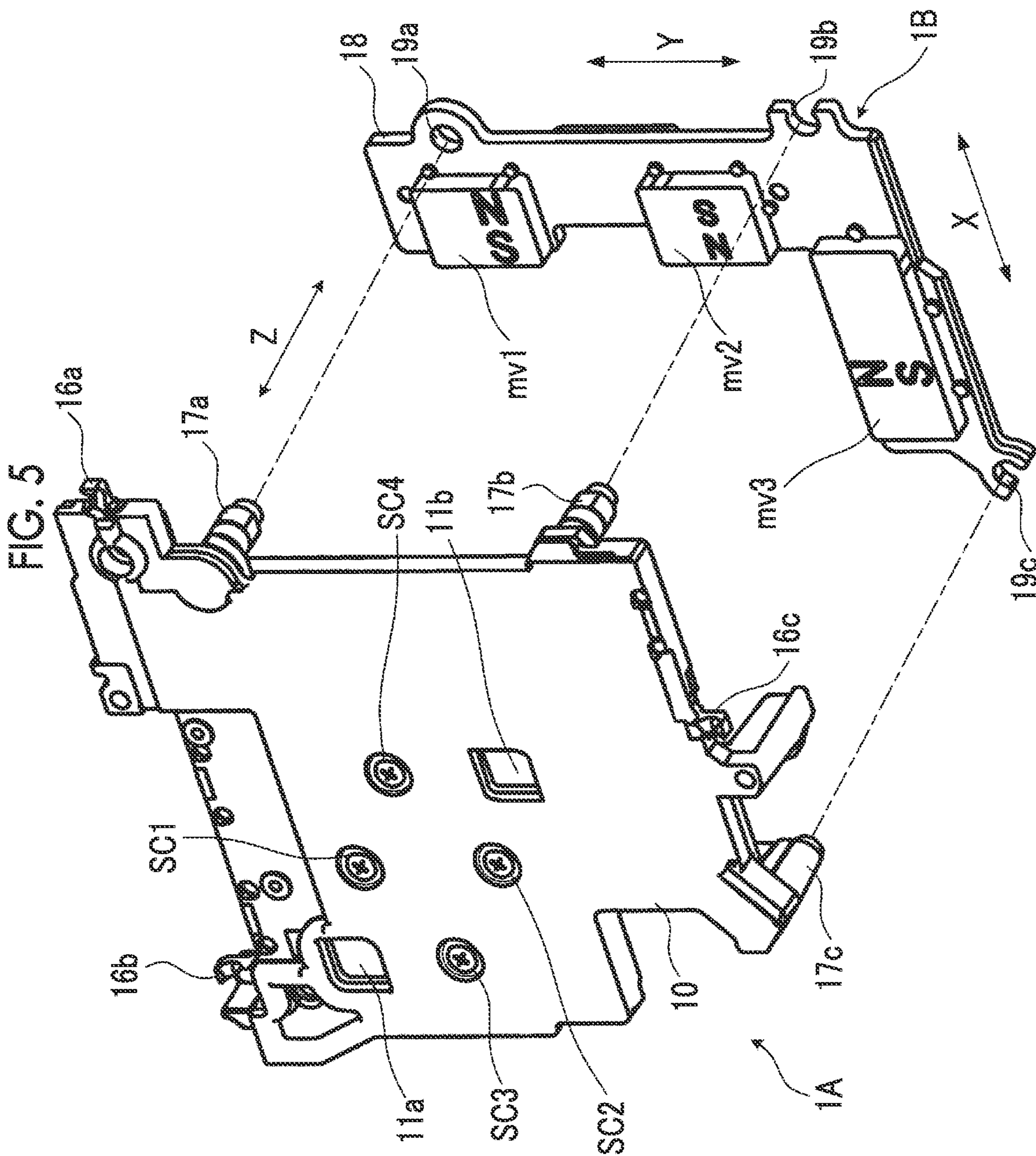


FIG. 6

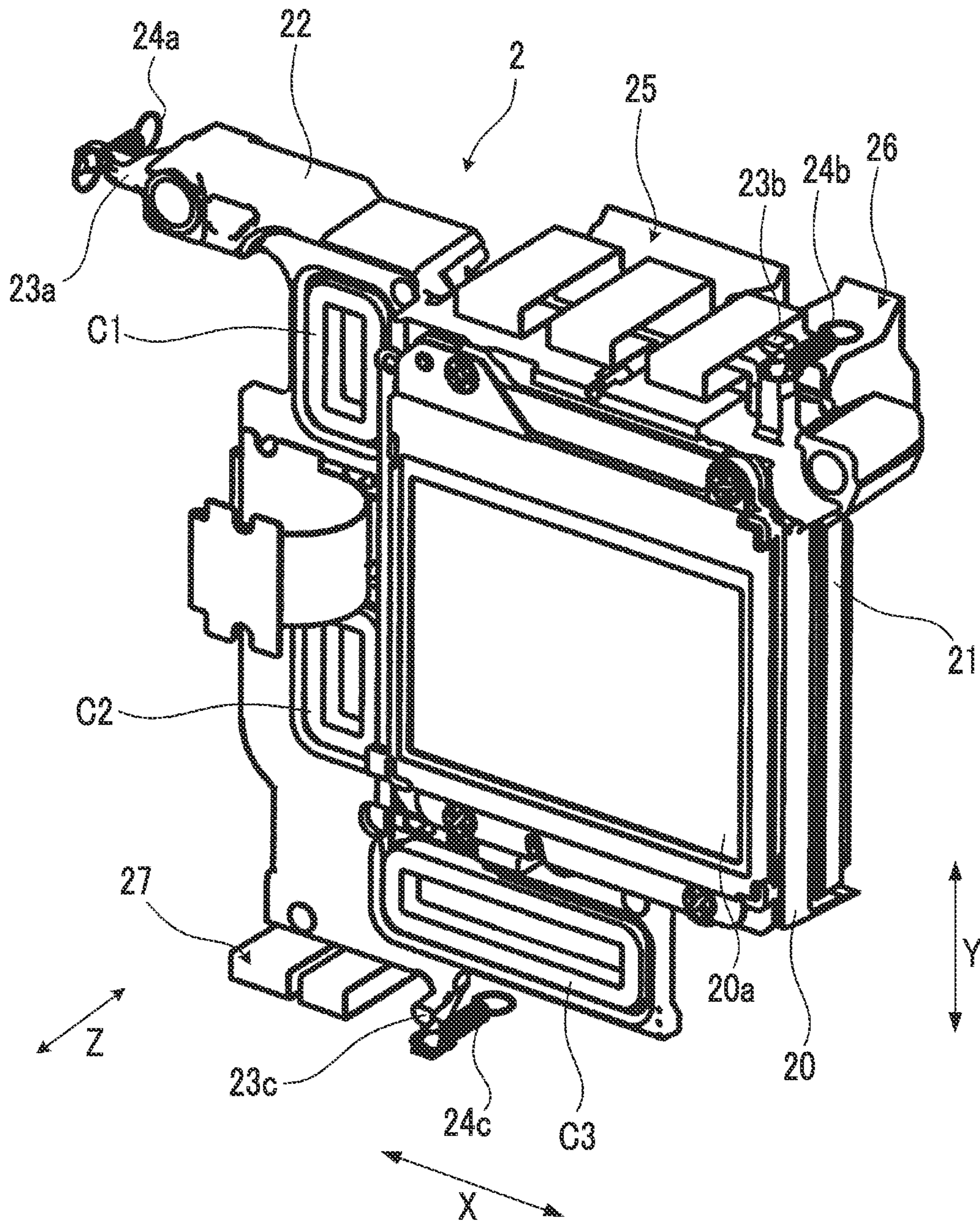




FIG. 7

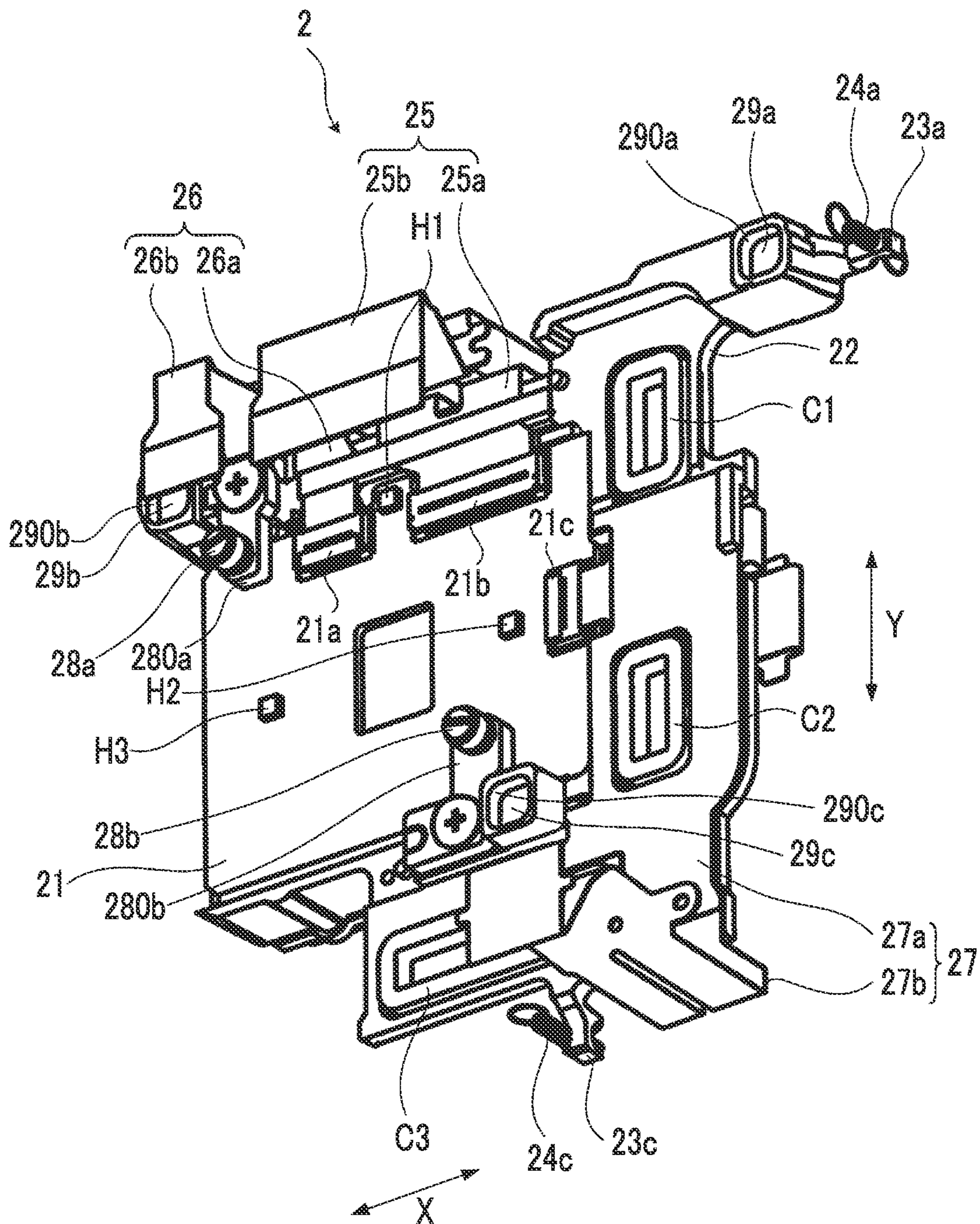


FIG. 8

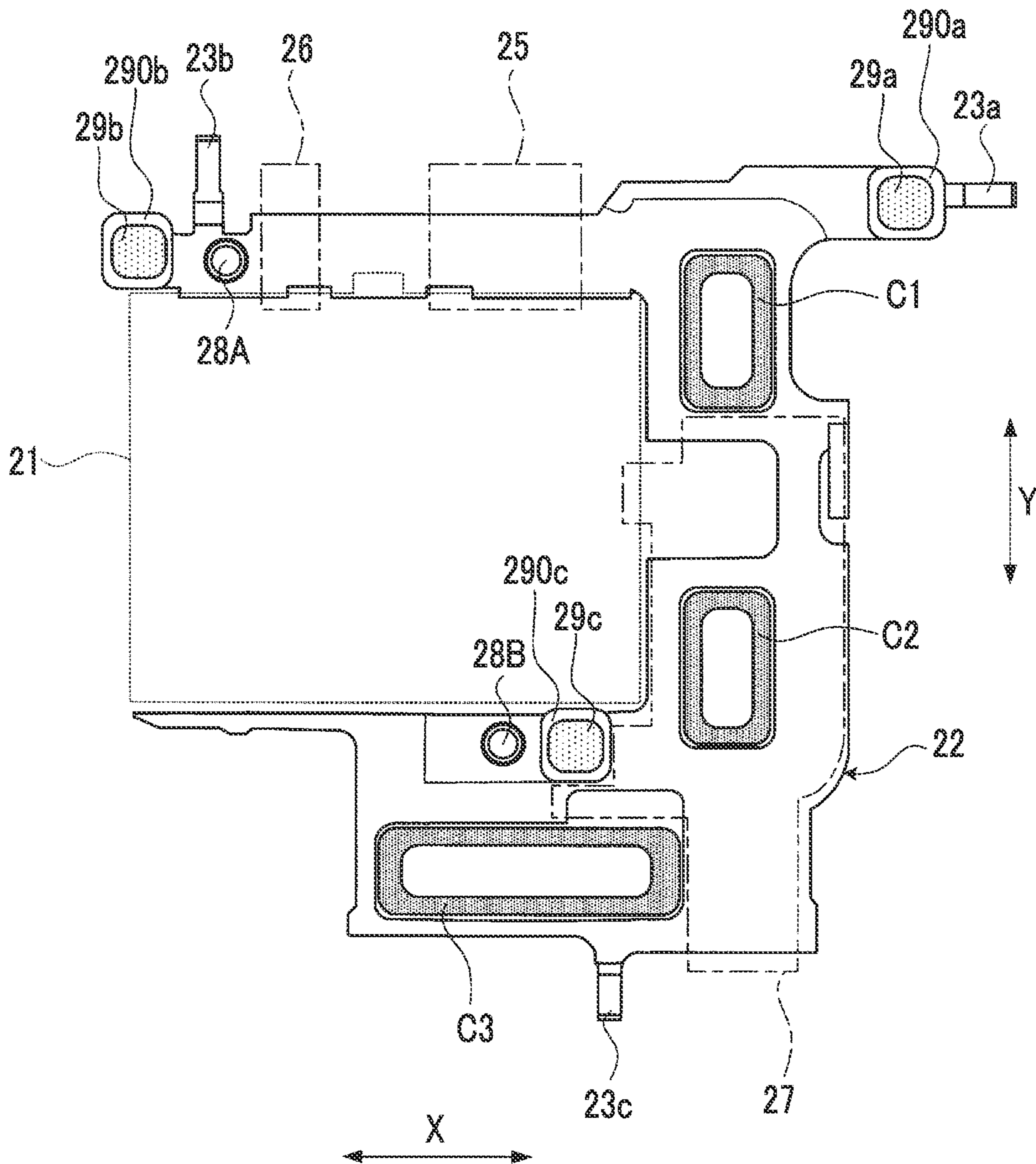


FIG. 9

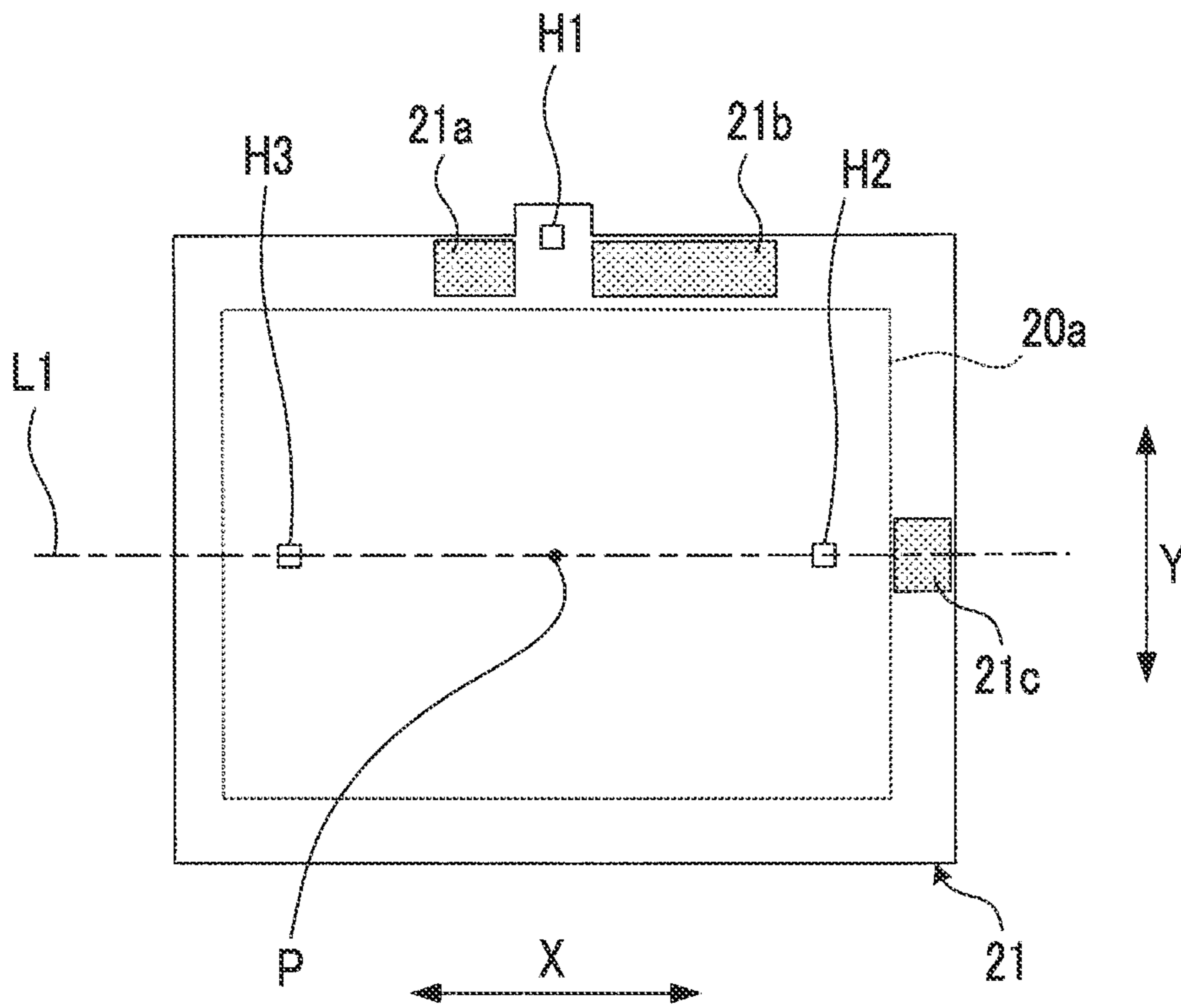


FIG. 10

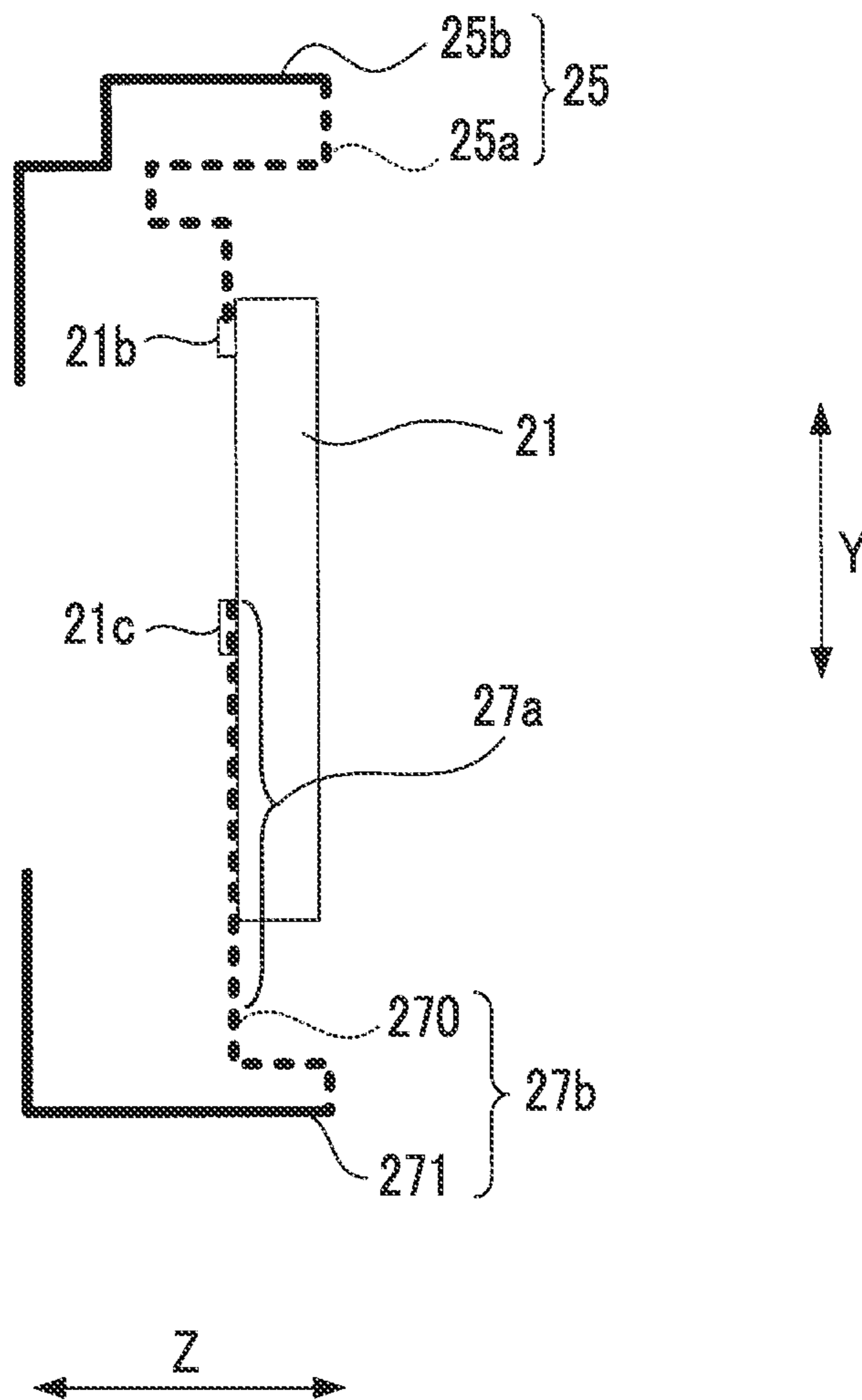


FIG. 11

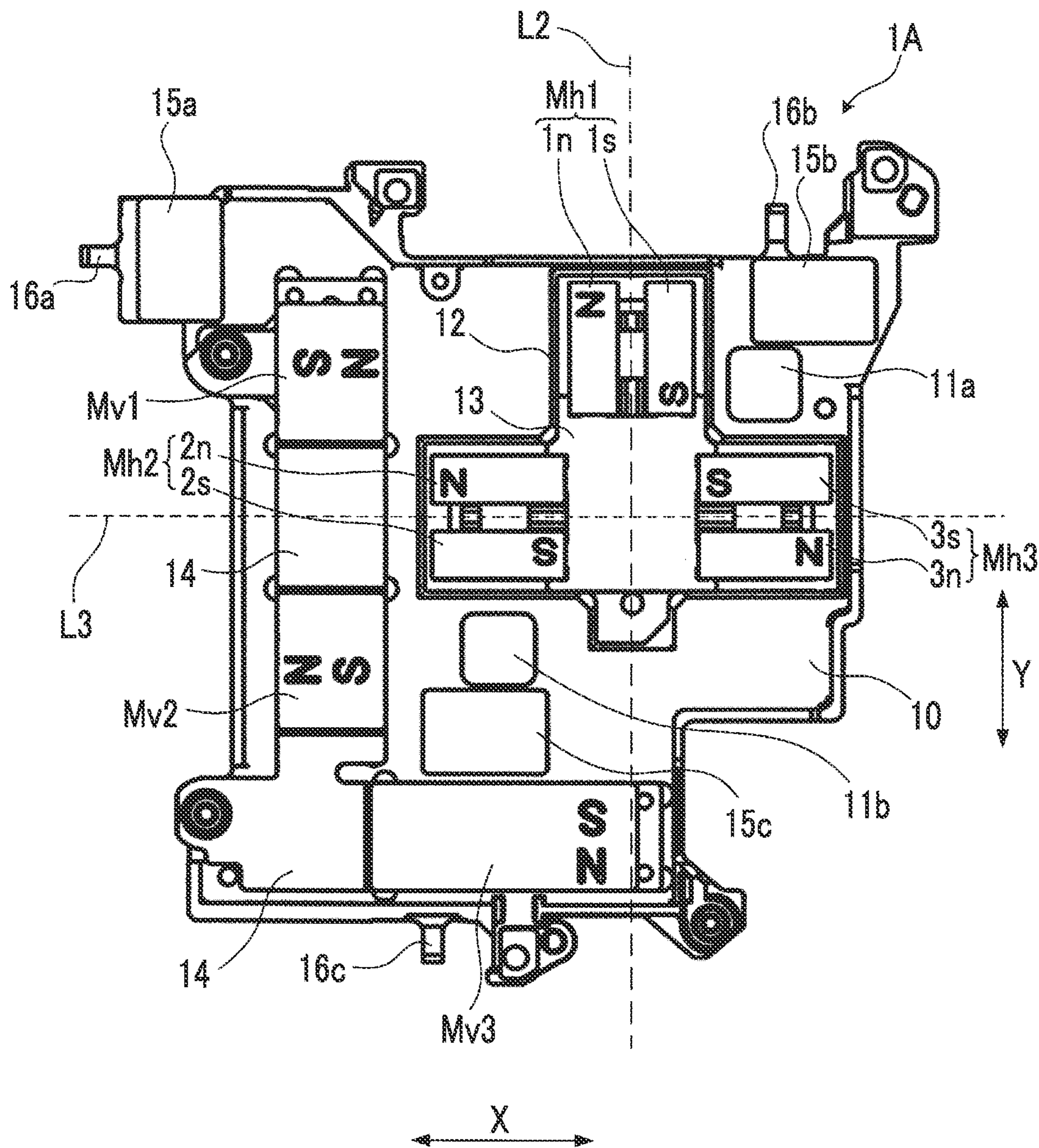


FIG. 12

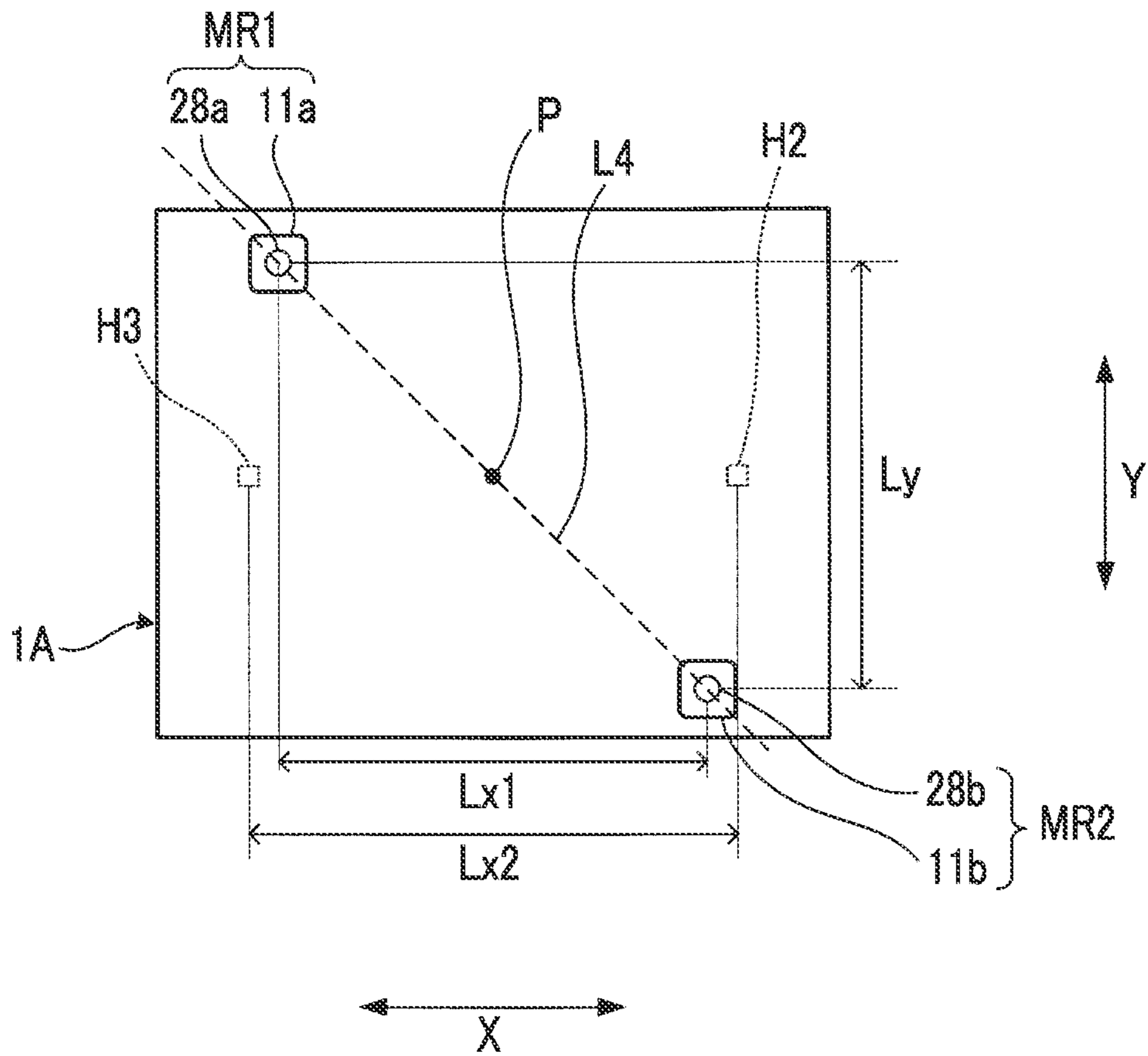


FIG. 13

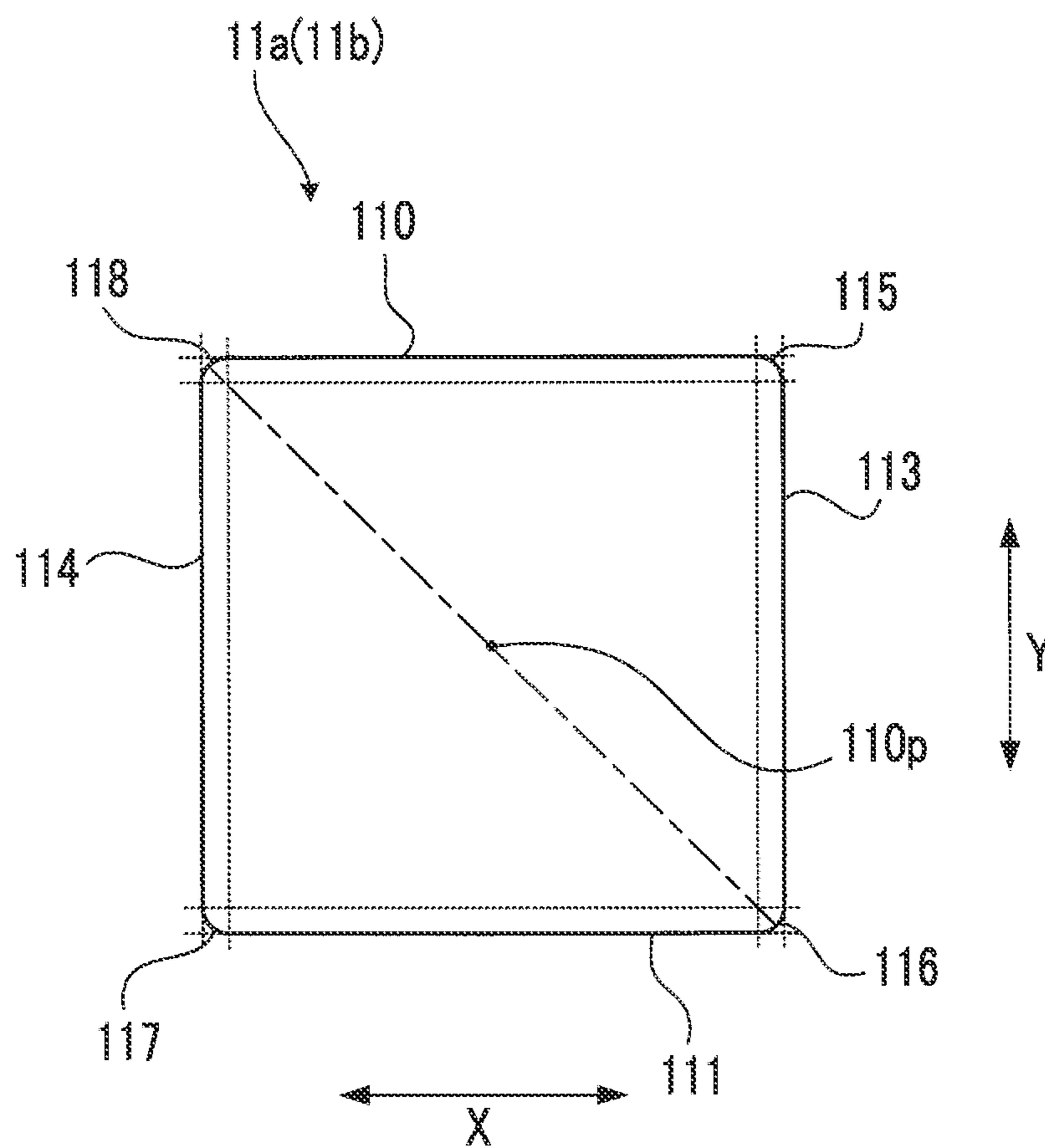


FIG. 14

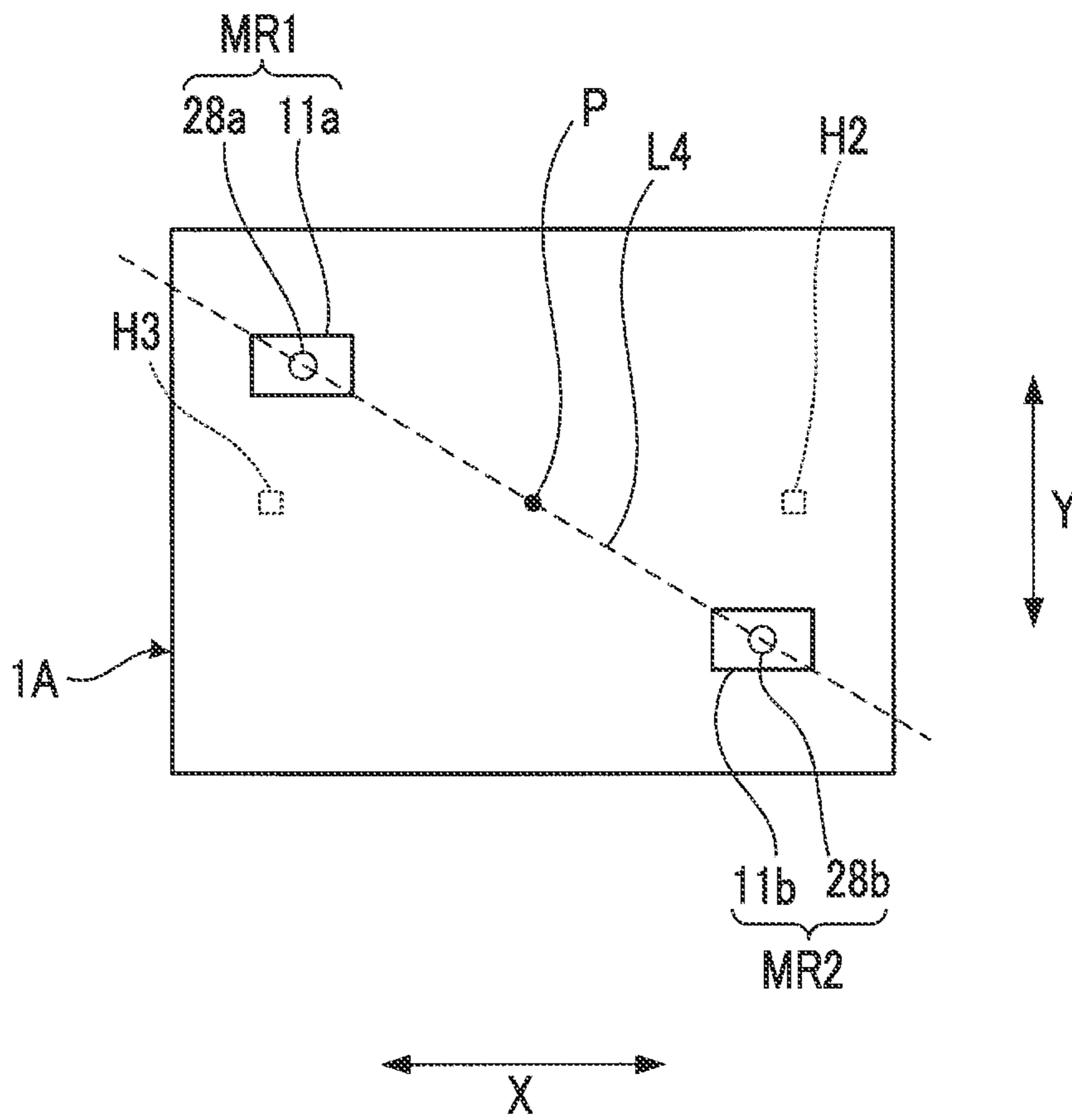




FIG. 15

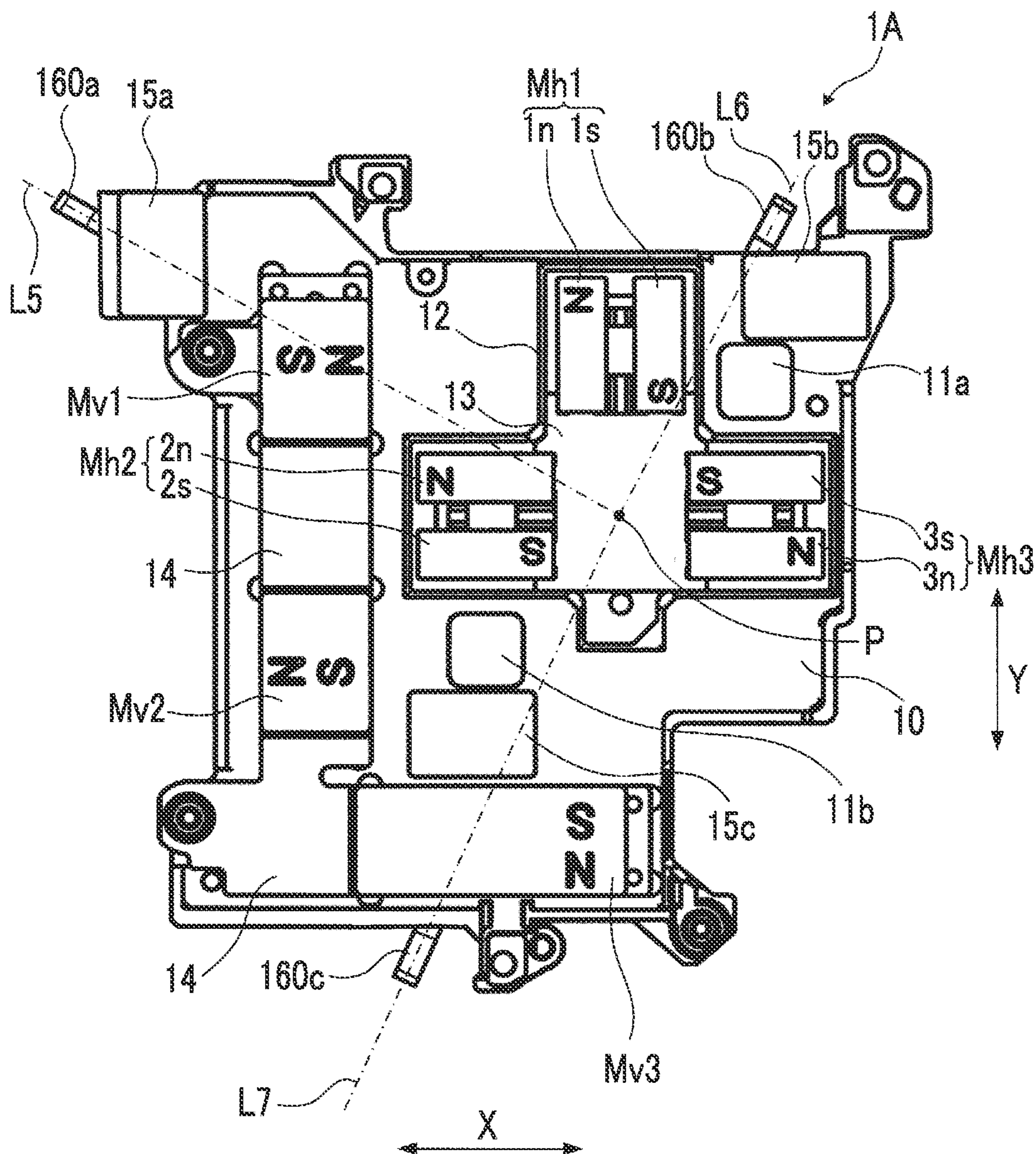


FIG. 16

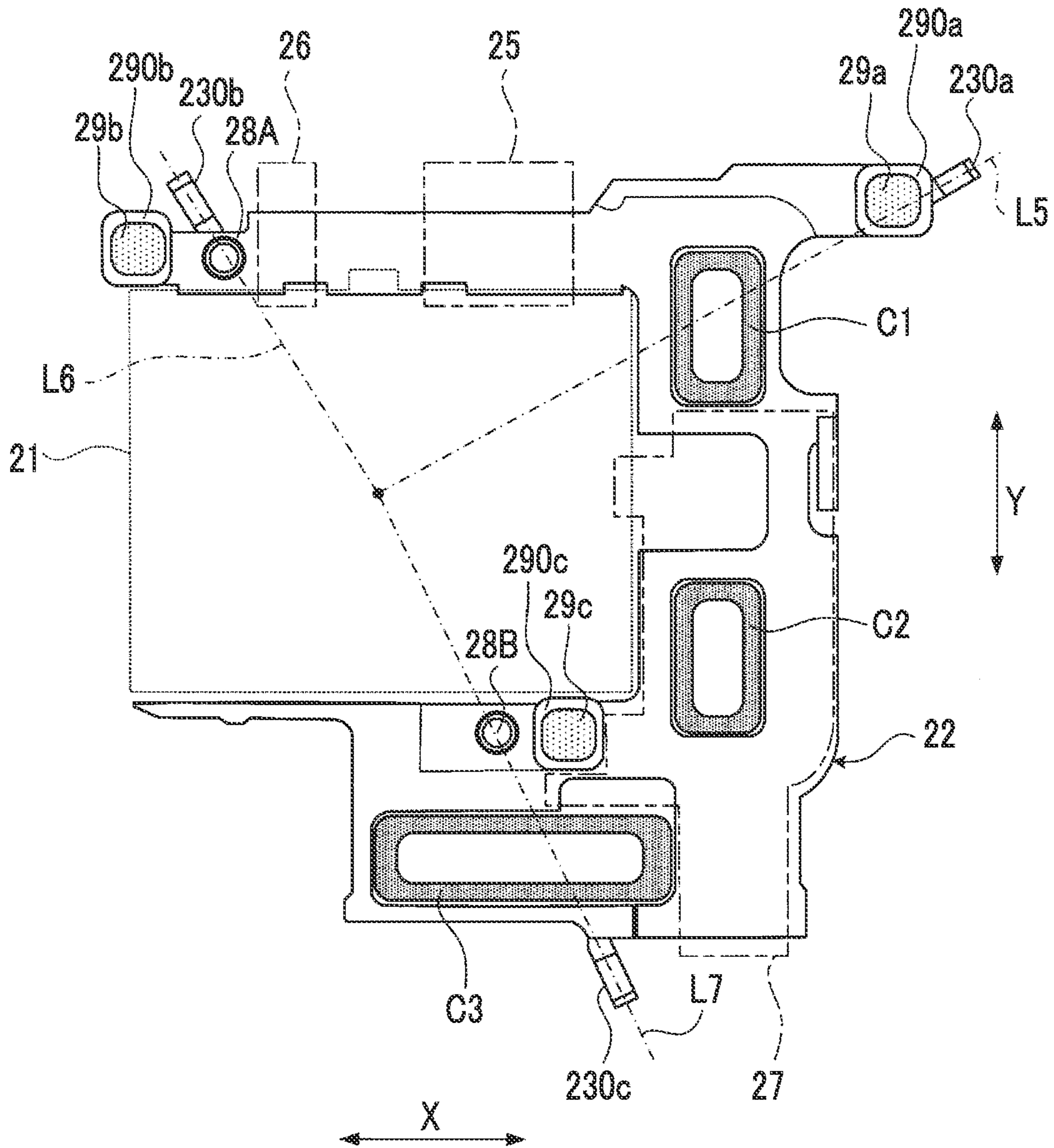


FIG. 17

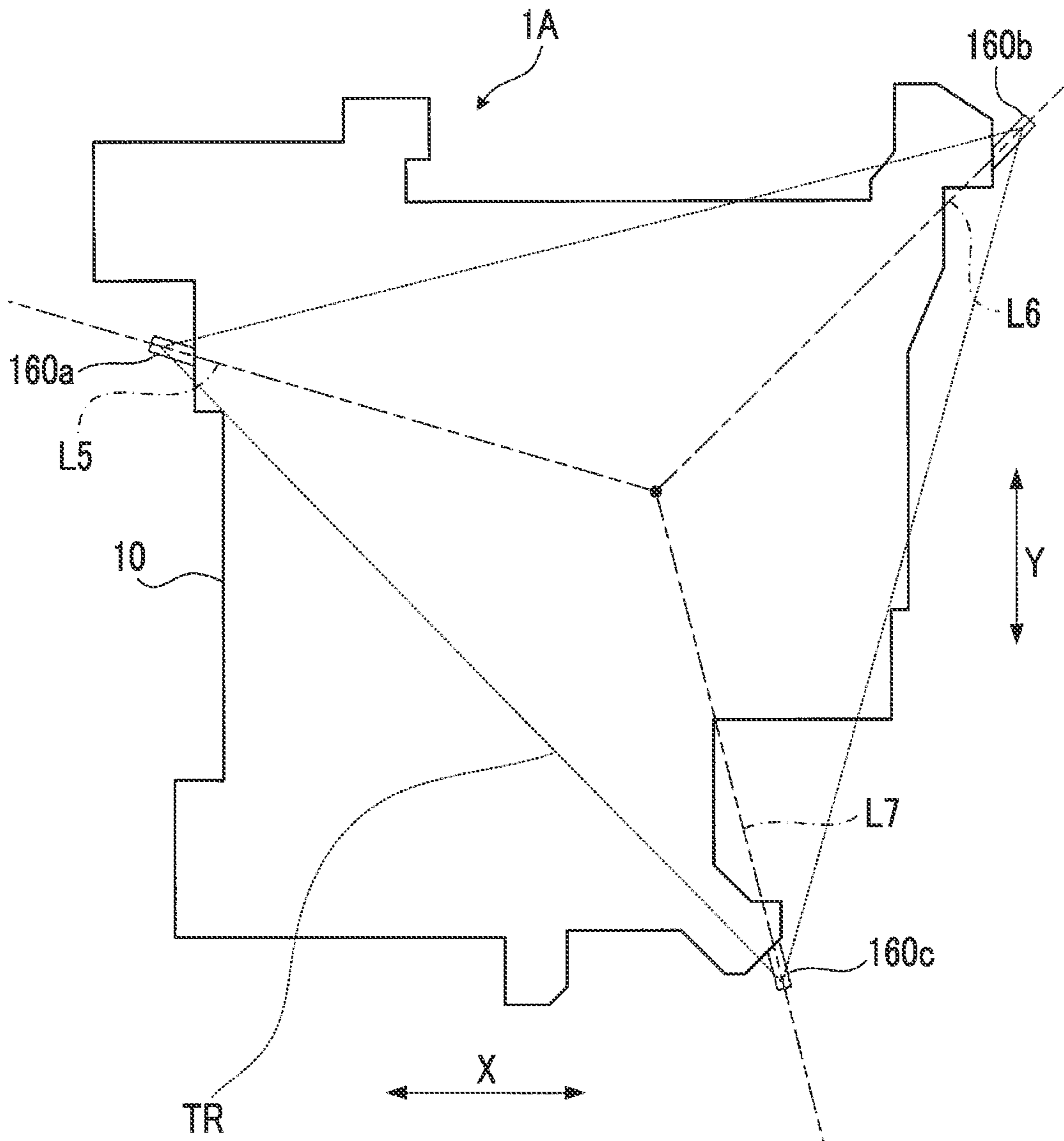


FIG. 18

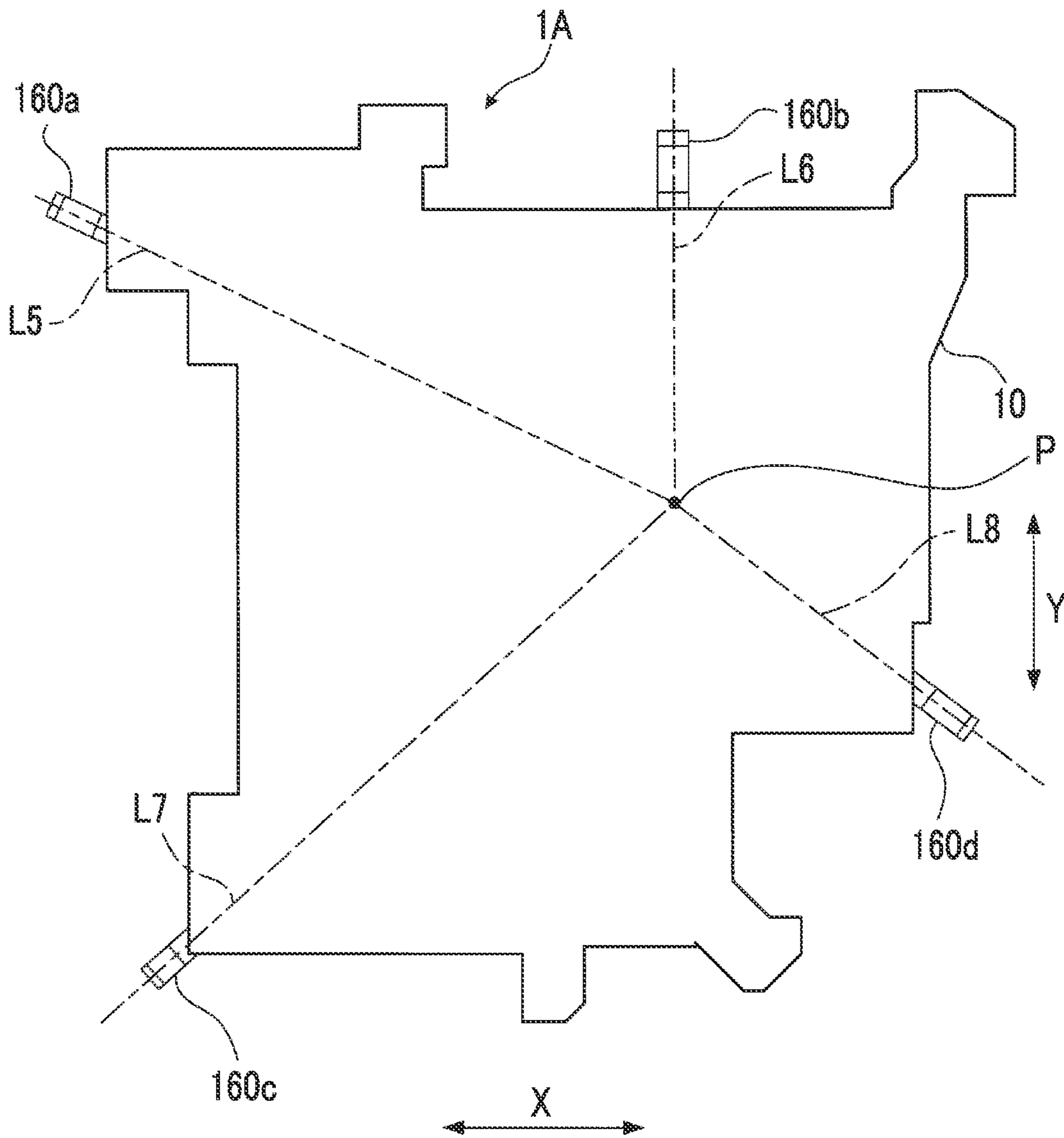


FIG. 19

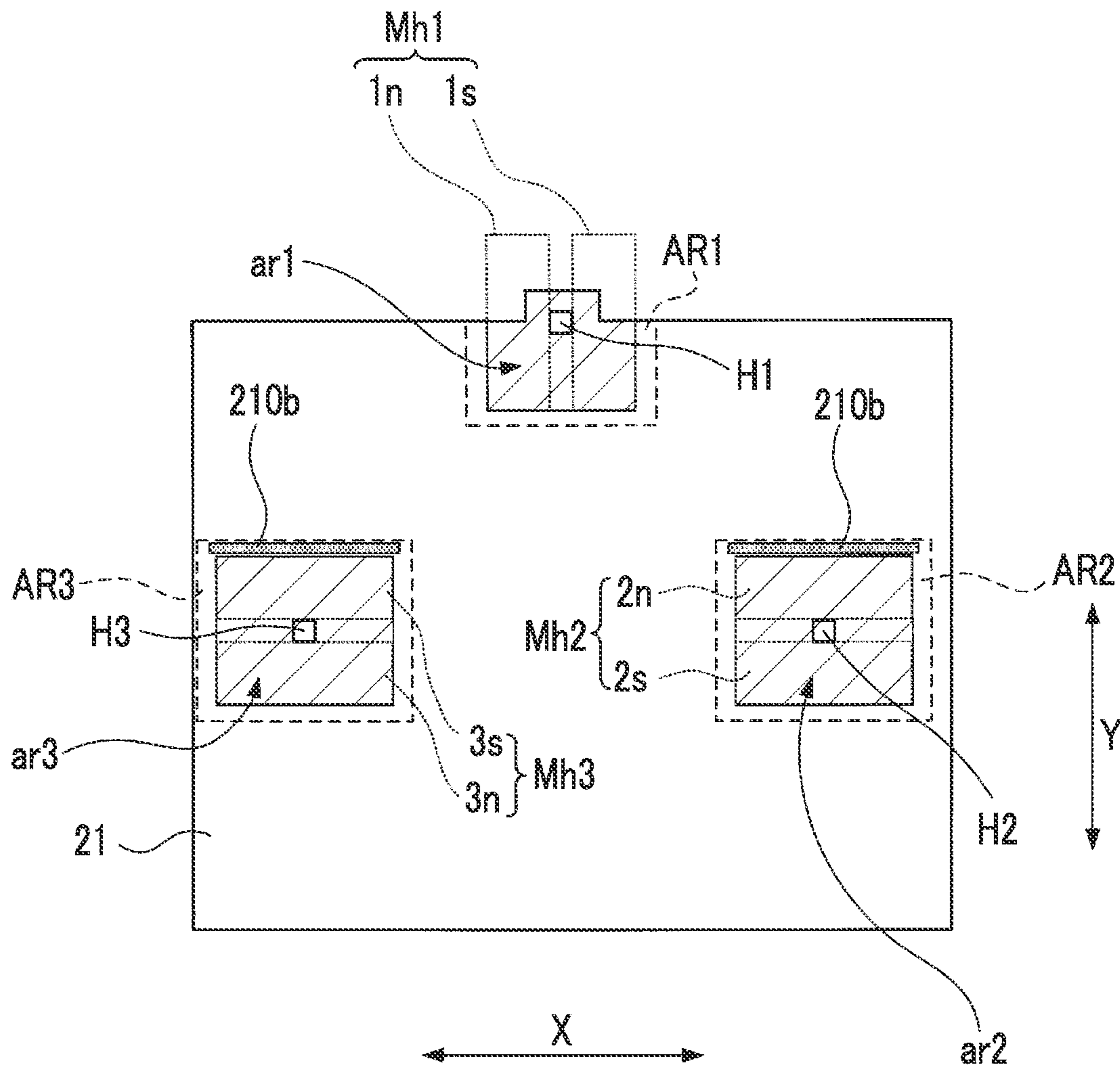


FIG. 20

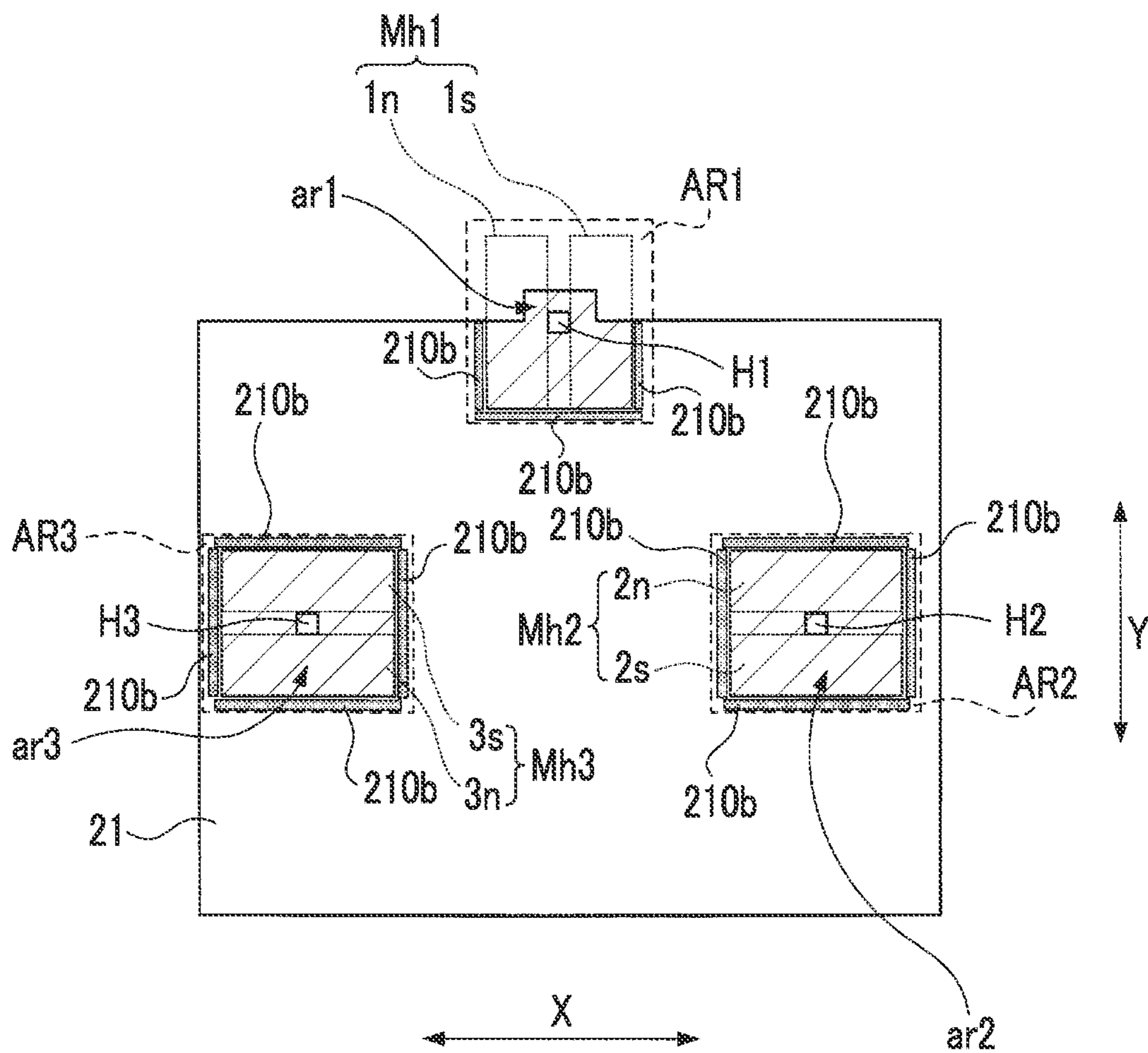


FIG. 21

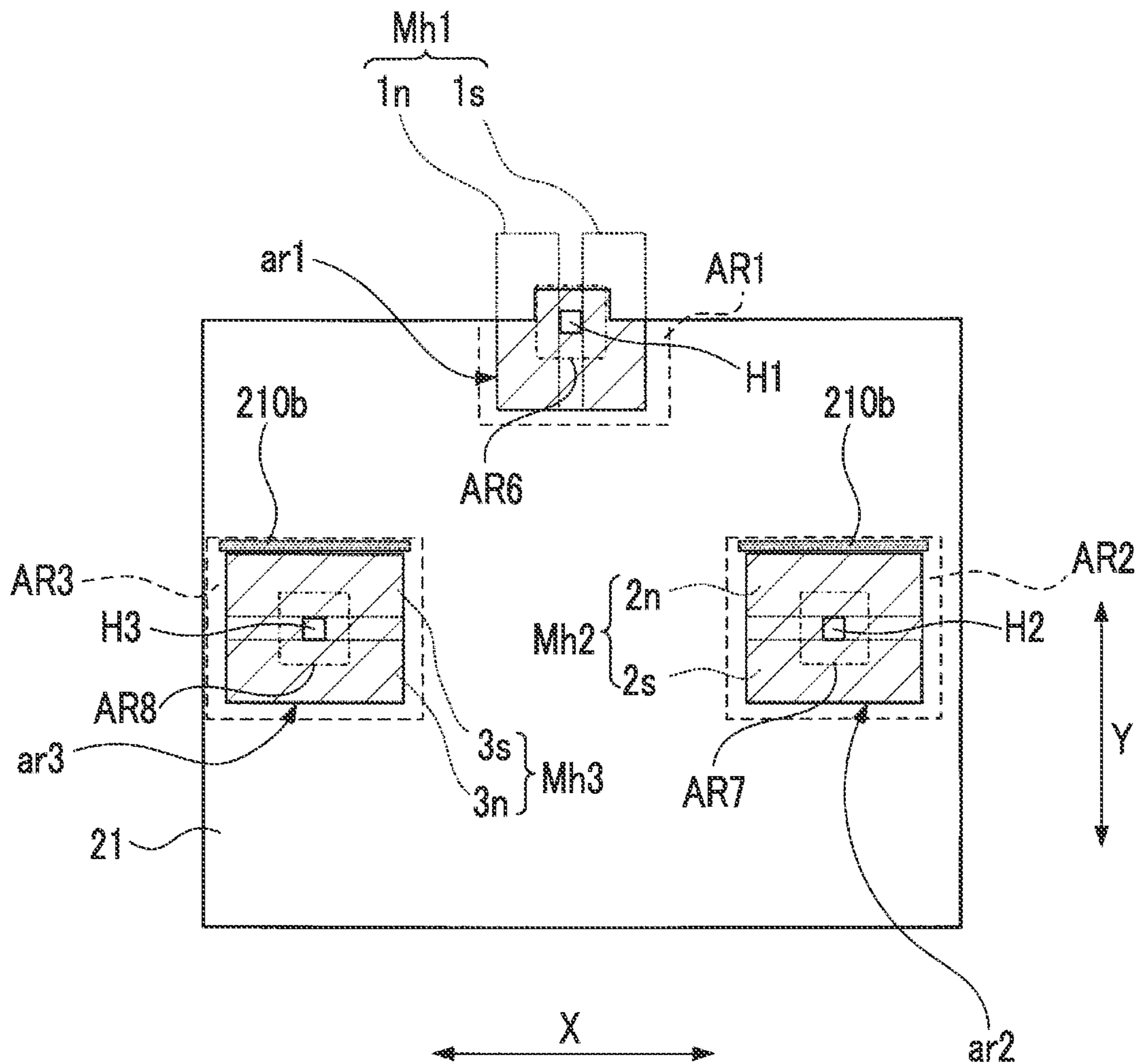


FIG. 22

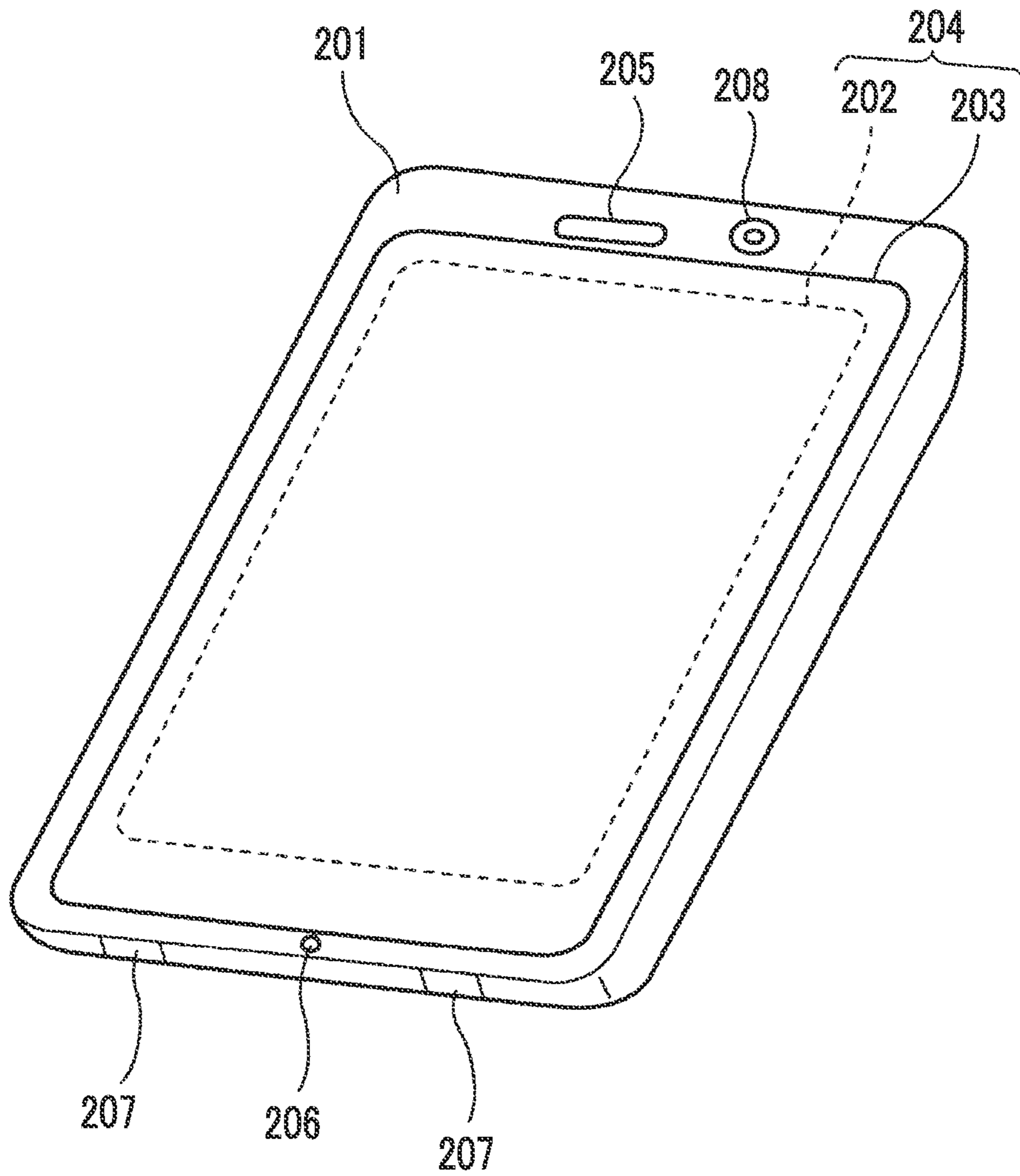
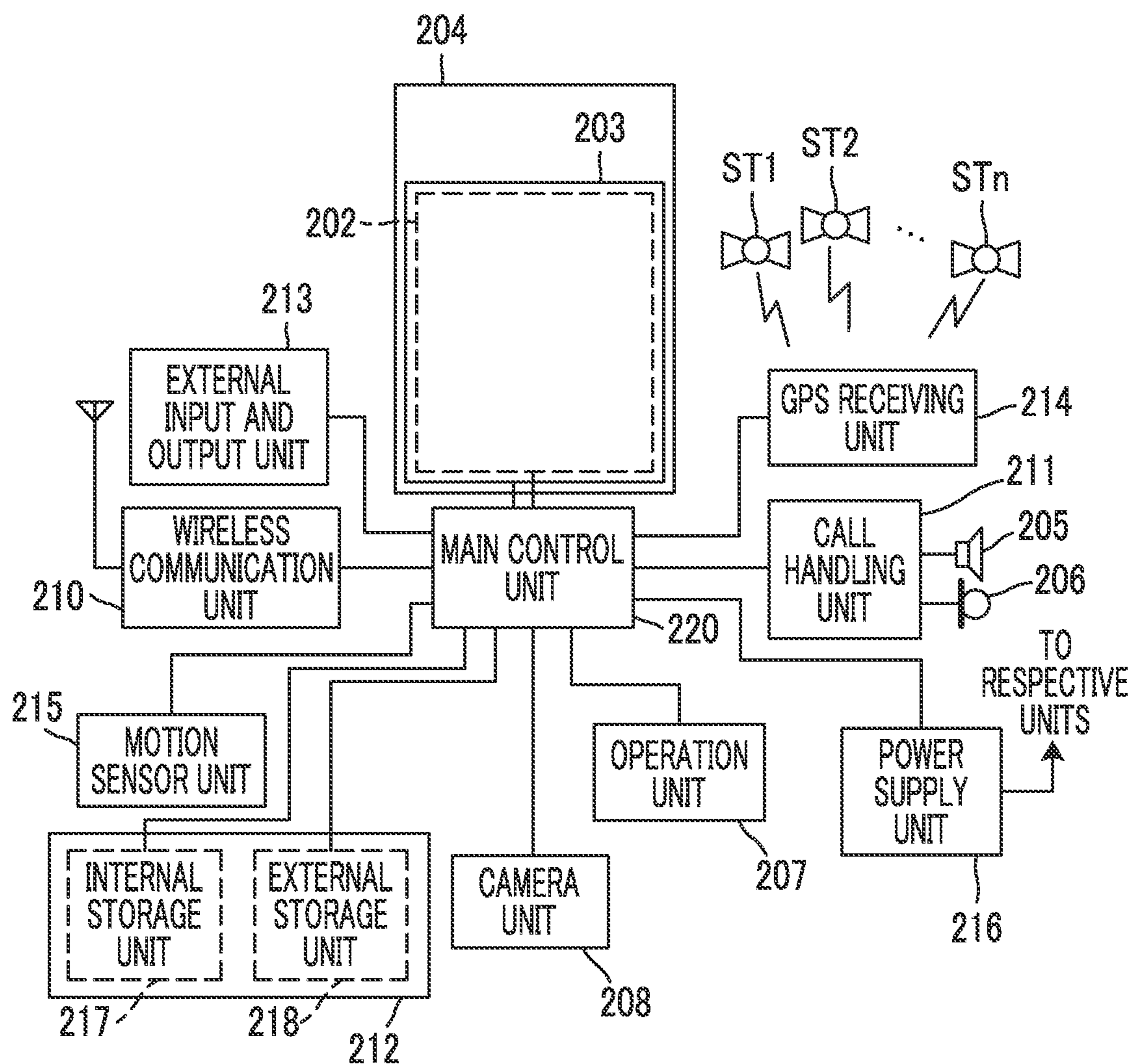




FIG. 23



# IMAGE SHAKE CORRECTION DEVICE AND IMAGING DEVICE

## CROSS REFERENCE TO RELATED APPLICATION

This is a continuation application of U.S. patent application Ser. No. 17/116,873 filed on Dec. 9, 2020, which is a continuation application of U.S. patent application Ser. No. 16/831,690 filed on Mar. 26, 2020, which is a continuation of International Application No. PCT/JP2018/035901 filed on Sep. 27, 2018, and claims priority from Japanese Patent Application No. 2017-186876 filed on Sep. 27, 2017, the entire disclosures of which are incorporated herein by reference.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to an image shake correction device and an imaging device.

### 2. Description of the Related Art

An imaging device comprising an imager that images a subject through an imaging optical system or a lens device used by being attached to the imaging device has an image shake correction function of correcting shake (hereinafter, referred to as image shake) of a captured image caused by vibration of the apparatus.

For example, in the lens device, image shake correction is performed by moving a correction lens included in an imaging optical system in a surface perpendicular to an optical axis such that the vibration of the apparatus is detected based on information from a motion detection sensor such as an acceleration sensor or angular velocity sensor mounted on the lens device and the detected vibration is canceled.

In the imaging device, the image shake correction is performed by moving one or both of the correction lens included in the imaging optical system and the imager on a surface perpendicular to an optical axis such that the vibration of the apparatus is detected based on information from a motion detection sensor such as an acceleration sensor or an angular velocity sensor mounted on the imaging device and the detected vibration is canceled.

JP2015-040866A describes an image shake correction device that performs the image shake correction by moving the correction lens.

JP2007-199583A describes an image shake correction device that performs the image shake correction by moving the imager.

## SUMMARY OF THE INVENTION

In the image shake correction device that performs the image shake correction by moving the imager, since a light receiving surface of the imager has a rectangular shape, the imager is also moved in a rotation direction using a center of the light receiving surface as a rotation center in addition to a horizontal direction and a vertical direction in some cases.

In the configuration in which the imager is rotated, it is necessary to provide two rotation restriction units for restricting the rotation of the movable unit including the imager. It is necessary to device the arrangement of the two

rotation restriction units in order to secure the maximum rotation amount of the imager.

JP2015-040866A performs the image shake correction by moving the correction lens, and does not consider that the imager is rotated.

JP2007-199583A does not assume that the imager is rotated, and does not recognize the problem of securing the rotation amount.

The present invention has been made in view of the above circumstances, and an object of the present invention is to provide an image shake correction device capable of improving image shake correction performance by securing the maximum rotation amount of an imager in a case where image shake is corrected by rotating the imager, and an imaging device comprising the image shake correction device.

An image shake correction device of the present invention comprises a movable member, an imager that is fixed to the movable member, a support member that supports the movable member to be movable, and two movement restrictors that restrict a movement range of the movable member. Each of the two movement restrictors includes a recess portion or a through-hole formed in one of the movable member and the support member, and an insertion member formed in the other one of the movable member and the support member and inserted into the recess portion or the through-hole, a shape of the recess portion or the through-hole as viewed in a direction perpendicular to a light receiving surface of the imager is a rectangle, and in a state in which the insertion members are present in centers of the two recess portions or through-holes, a second diagonal line of a second one of the two rectangles overlaps an extension line of a first diagonal line of a first one of the two rectangles, and a center of the light receiving surface overlaps a line connecting the first diagonal line and the second diagonal line.

The imaging device of the present invention includes the image shake correction device.

According to the present invention, it is possible to provide an image shake correction device capable of improving image shake correction performance by securing the maximum rotation amount of an imager in a case where image shake is corrected by rotating the imager, and an imaging device comprising the image shake correction device.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing a schematic configuration of a digital camera **100** which is an embodiment of an imaging device of the present invention.

FIG. 2 is a diagram showing a schematic configuration of an image shake correction device **3** in the digital camera **100** shown in FIG. 1.

FIG. 3 is a perspective view showing an appearance configuration of the image shake correction device **3** shown in FIGS. 1 and 2.

FIG. 4 is an exploded perspective view of a support member **1** in a case where the support member **1** in the image shake correction device **3** shown in FIG. 3 is viewed from an imaging optical system **101** side.

FIG. 5 is an exploded perspective view of the support member **1** shown in FIG. 4 as viewed from a side opposite to the imaging optical system **101** side.

FIG. 6 is a perspective view of a movable member **2** in the image shake correction device **3** shown in FIG. 3 as viewed from the imaging optical system **101** side.

## 3

FIG. 7 is a perspective view of the movable member 2 shown in FIG. 6 as viewed from the side opposite to the imaging optical system 101 side.

FIG. 8 is a plan view of the movable member 2 shown in FIG. 6 as viewed from the side opposite to the imaging optical system 101 side.

FIG. 9 is a diagram showing a state in which a rear surface of a circuit board 21 fixed to the movable member 2 shown in FIG. 7 is viewed in a direction Z.

FIG. 10 is a side view showing a state in which the circuit board 21 fixed to the movable member 2 shown in FIG. 6 and a flexible print substrate connected to the circuit board are viewed in a direction X.

FIG. 11 is a front view of a first support member 1A shown in FIG. 4 as viewed from the imaging optical system 101 side.

FIG. 12 is a schematic diagram showing a state in which the first support member 1A shown in FIG. 5 is viewed in the direction Z from the side opposite to the imaging optical system 101 side.

FIG. 13 is an enlarged view of a through-hole 11a shown in FIG. 12.

FIG. 14 is a diagram showing a modification example of movement restrictors MR1 and MR2 shown in FIG. 12.

FIG. 15 is a diagram showing a modification example of the first support member 1A shown in FIG. 11.

FIG. 16 is a diagram showing a modification example of a base 22 of the movable member 2 shown in FIG. 8.

FIG. 17 is a diagram showing a modification example of the arrangement of hooks 160a to 160c shown in FIG. 15 in the base 10.

FIG. 18 is a diagram showing another modification example of the first support member 1A shown in FIG. 11.

FIG. 19 is a schematic diagram showing a preferable configuration example of the rear surface of the circuit board 21 in the image shake correction device 3.

FIG. 20 is a diagram showing a first modification example of the circuit board 21 shown in FIG. 19.

FIG. 21 is a diagram showing a second modification example of the circuit board 21 shown in FIG. 19.

FIG. 22 shows an appearance of a smartphone 200 that is an embodiment of an imaging device of the present invention.

FIG. 23 is a block diagram showing a configuration of the smartphone 200 shown in FIG. 22.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, embodiments of the present invention will be described with reference to the drawings.

FIG. 1 is a diagram showing a schematic configuration of a digital camera 100 which is an embodiment of an imaging device of the present invention.

The digital camera 100 comprises an imaging optical system 101, an imager 20, an image shake correction device 3, an imager drive unit 105 that drives the imager 20, an analog front end (AFE) 104, an image processing unit 107, a motion detection sensor 106, and a system controller 108 that performs overall control of the entire digital camera 100.

The imaging optical system 101 includes a focus lens or a zoom lens, and a stop.

The imager 20 images a subject through the imaging optical system 101, and comprises a semiconductor chip on which a charge coupled device (CCD) image sensor or a

## 4

complementary metal oxide semiconductor (CMOS) image sensor is formed and a package that accommodates the semiconductor chip.

As shown in FIG. 3 to be described below, a light receiving surface 20a of the imager 20 has a rectangular shape.

The image shake correction device 3 corrects image shake of a captured image captured by the imager 20 by moving the light receiving surface 20a of the imager 20 within a surface perpendicular to an optical axis K of the imaging optical system 101.

In the present specification, in the digital camera 100, the light receiving surface 20a of the imager 20 is perpendicular to a gravity direction (the optical axis K is parallel to the gravity direction), and a state in which the image shake correction device 3 is not energized is a reference state. In this reference state, a center P (see FIG. 3) of the light receiving surface 20a is located on the optical axis K.

Although the detailed configuration of the image shake correction device 3 will be described below, the image shake is corrected by moving the imager 20 in three directions of a first direction which is a longitudinal direction (direction X shown in FIG. 3) of the light receiving surface 20a of the imager 20 in the reference state, a second direction which is a short direction (direction Y shown in FIG. 3) of the light receiving surface 20a of the imager 20 in the reference state, and a third direction which is a direction (direction  $\theta$  shown in FIG. 3) along a circumference of a circle using the center P of the light receiving surface 20a of the imager 20 in this reference state as a center.

The AFE 104 includes a signal processing circuit that performs correlative double sampling processing and digital conversion processing on imaging signals output from the imager 20.

The image processing unit 107 performs digital signal processing on the imaging signals processed by the AFE 104, and generates captured image data such as a Joint Photographic Experts Group (JPEG) format.

The motion detection sensor 106 is a sensor that detects the movement of the digital camera 100, and includes an acceleration sensor, an angular velocity sensor, or both thereof.

The system controller 108 controls the imager drive unit 105 and the AFE 104 such that the subject is captured by the imager 20 and the imaging signal corresponding to a subject image is output from the imager 20.

The system controller 108 controls the image shake correction device 3 based on movement information of the digital camera 100 detected by the motion detection sensor 106. The system controller 108 corrects the image shake of the captured image captured by the imager 20 by moving the light receiving surface 20a of the imager 20 in at least one of the direction X, the direction Y, and the direction  $\theta$ .

In a state in which the image shake correction device 3 is energized, in a case where the movement of the digital camera 100 is not detected by the motion detection sensor 106, the system controller 108 controls the image shake correction device 3 such that a position of the light receiving surface 20a of the imager 20 is a position in the reference state.

FIG. 2 is a diagram showing a schematic configuration of the image shake correction device 3 in the digital camera 100 shown in FIG. 1.

The image shake correction device 3 comprises a movable member 2 movable in each of the directions X, Y, and  $\theta$ , and a support member that supports the movable member 2 to be movable in each of the directions X, Y, and  $\theta$ .

## 5

A circuit board **21** on which the imager **20** is fixed (mounted), an X-axis rotation drive coil **C1**, an X-axis rotation drive coil **C2**, and a Y-axis drive coil **C3** are fixed to the movable member **2**.

An X-axis position detection Hall element **H1** that is a position detector for detecting a position of the movable member **2** in the direction **X**, and a Y-axis rotation position detection Hall element **H2** and a Y-axis rotation position detection Hall element **H3** which are position detectors for detecting positions of the movable member **2** in the direction **Y** and the direction  $\theta$  are fixed to the circuit board **21**.

Output signals of the X-axis position detection Hall element **H1**, the Y-axis rotation position detection Hall element **H2**, and the Y-axis rotation position detection Hall element **H3** are input to the system controller **108**.

The system controller **108** moves the movable member **2** by controlling a control current flowing through the X-axis rotation drive coil **C1**, a control current flowing through the X-axis rotation drive coil **C2**, and a control current flowing through the Y-axis drive coil **C3** based on the output signals, and corrects the image shake.

The support member **1** includes a first support member **1A** and a second support member **1B**.

An X-axis rotation drive magnet **Mv1**, an X-axis rotation drive magnet **Mv2**, a Y-axis drive magnet **Mv3**, an X-axis position detection magnet **Mh1**, a Y-axis rotation position detection magnet **Mh2**, and a Y-axis rotation position detection magnet **Mh3** are fixed to the first support member **1A**.

The X-axis rotation drive magnet **mv1**, the X-axis rotation drive magnet **mv2**, and the Y-axis drive magnet **mv3** are fixed to the second support member **1B**.

FIG. **3** is a perspective view showing an appearance configuration of the image shake correction device **3** shown in FIGS. **1** and **2**. FIG. **3** shows an appearance of the image shake correction device **3** in the reference state.

As shown in FIG. **3**, the image shake correction device **3** comprises the support member **1** constituted by the first support member **1A** and the second support member **1B** and the movable member **2** to which the circuit board **21** on which the imager **20** is mounted is fixed. The movable member **2** is biased against the first support member **1A** by springs **24a**, **24b**, and **24c** which are elastic members.

The springs **24a**, **24b**, and **24c** may be any springs that can urge the movable member **2** to the first support member **1A** by an elastic force, and may be replaced with rubber which is an elastic member, for example.

This image shake correction device **3** is fixed to a main body of the digital camera **100** in a state in which the light receiving surface **20a** faces the imaging optical system **101** shown in FIG. **1**.

The image shake correction device **3** corrects the image shake by moving the movable member **2** in the direction  $\theta$  using, as a center, a rotation axis **R** (an axis which is parallel to the gravity direction and passes through the center **P** in the reference state) which is perpendicular to the light receiving surface **20a** and passes through the center **P** of the light receiving surface **20a**, the direction **X** which is the longitudinal direction of the light receiving surface **20a**, and the direction **Y** which is the short direction of the light receiving surface **20a**.

Hereinafter, a direction in which the rotation axis **R** extends is referred to as a direction **Z**. A flat surface perpendicular to the rotation axis **R** is a flat surface on which the movable member **2** moves.

## 6

The movable member **2** is movable in one direction (left direction) of the direction **X** and the other direction (right direction) of the direction **X** from the reference state by the same distance.

The movable member **2** is movable in one direction (up direction) of the direction **Y** and the other direction (down direction) of the direction **Y** from the reference state by the same distance.

The movable member **2** is rotatable in one direction (right rotation direction) of the direction  $\theta$  and the other direction (left rotation direction) of the direction  $\theta$  from the reference state by the same angle.

In the digital camera **100** shown in FIG. **1**, a posture in which the direction **Y** shown in FIG. **3** is parallel to the gravity direction is a normal posture (a posture for performing so-called horizontal imaging).

FIG. **4** is an exploded perspective view of the support member **1** in the image shake correction device **3** shown in FIG. **3** as viewed from the imaging optical system **101** side.

FIG. **5** is an exploded perspective view of the support member **1** shown in FIG. **4** as viewed from a side opposite to the imaging optical system **101** side.

As shown in FIGS. **4** and **5**, the first support member **1A** comprises a plate-like base **10** that is made of resin and has a flat surface perpendicular to the direction **Z**, and projecting portions **17a**, **17b**, and **17c** extending in the direction **Z** from a peripheral portion of the base **10** to the imaging optical system **101** side.

The second support member **1B** has a substantially L-shaped yoke **18** as viewed from the imaging optical system **101** side. A hole portion **19a** and notch portions **19b** and **19c** at positions facing the projecting portions **17a**, **17b** and **17c** are formed at the yoke **18**.

In a state in which the movable member **2** is disposed between the first support member **1A** and the second support member **1B**, the projecting portion **17a** of the first support member **1A** is fixed by being fitted into the hole portion **19a** of the second support member **1B**, the projecting portion **17b** of the first support member **1A** is fixed by being fitted into the notch portion **19b** of the second support member **1B**, and the projecting portion **17c** of the first support member **1A** is fixed by being fitted into the notch portion **19c** of the second support member **1B**. Accordingly, the movable member **2** is supported by the support member **1**.

As shown in FIG. **4**, substantially L-shaped yokes **14** as viewed from the imaging optical system **101** side are formed at a left end portion in the direction **X** and a lower end portion in the direction **Y** as viewed from the imaging optical system **101** side on a surface of the base **10** on the imaging optical system **101** side.

The X-axis rotation drive magnet **Mv1** constituting a first drive magnet and the X-axis rotation drive magnet **Mv2** constituting a second drive magnet are arranged and fixed on a front surface of portions of the yokes **14** of the first support member **1A** that extends along the direction **Y** with a space in the direction **Y**.

As viewed from the imaging optical system **101** side, the X-axis rotation drive magnet **Mv1** is disposed such that an N-pole faces the right direction of the direction **X** and an S-pole faces the left direction of the direction **X**.

As viewed from the imaging optical system **101** side, the X-axis rotation drive magnet **Mv2** is disposed such that an N-pole faces the left direction of the direction **X** and an S-pole faces the right direction of the direction **X**.

The Y-axis drive magnet Mv3 constituting a third drive magnet is fixed on a front surface of a portion of the yoke 14 of the first support member 1A that extends along the direction X.

As viewed from the imaging optical system 101 side, the Y-axis drive magnet Mv3 is disposed such that an N-pole faces the down direction of the direction Y and an S-pole faces the up direction of the direction Y.

As shown in FIG. 5, the X-axis rotation drive magnet mv1 is fixed on a front surface of the yoke 18 of the second support member 1B on the first support member 1A side at a position facing the X-axis rotation drive magnet Mv1 of the first support member 1A with the X-axis rotation drive coil C1 of the movable member 2 described in FIG. 7 interposed therebetween.

An S-pole of the X-axis rotation drive magnet mv1 faces the N-pole of the X-axis rotation drive magnet Mv1 with the X-axis rotation drive coil C1 interposed therebetween. An N-pole of the X-axis rotation drive magnet mv1 faces the S-pole of the X-axis rotation drive magnet Mv1 with the X-axis rotation drive coil C1 interposed therebetween.

As shown in FIG. 5, the X-axis rotation drive magnet mv2 is fixed on a front surface of the yoke 18 of the second support member 1B on the first support member 1A side at a position facing the X-axis rotation drive magnet Mv2 of the first support member 1A with the X-axis rotation drive coil C2 of the movable member 2 described in FIGS. 6 to 8 interposed therebetween.

An S-pole of the X-axis rotation drive magnet mv2 faces the N-pole of the X-axis rotation drive magnet Mv2 with the X-axis rotation drive coil C2 interposed therebetween. An N-pole of the X-axis rotation drive magnet mv2 faces the S-pole of the X-axis rotation drive magnet Mv2 with the X-axis rotation drive coil C2 interposed therebetween.

As shown in FIG. 5, the Y-axis drive magnet mv3 is fixed on a front surface of the yoke 18 of the second support member 1B on the first support member 1A side at a position facing the Y-axis drive magnet Mv3 with the Y-axis drive coil C3 of the movable member 2 described in FIGS. 6 to 8 interposed therebetween.

An S-pole of the Y-axis drive magnet mv3 faces the N-pole of the Y-axis drive magnet Mv3 with the Y-axis drive coil C3 interposed therebetween. An N-pole of the Y-axis drive magnet mv3 faces the S-pole of the Y-axis drive magnet Mv3 with the Y-axis drive coil C3 interposed therebetween.

As shown in FIG. 4, substantially plus-shaped yokes 12 as viewed in the direction Z are formed at a portion facing the circuit board 21 fixed to the movable member 2 described in FIGS. 6 to 8 on a surface of the imaging optical system 101 side of the base 10 of the first support member 1A.

The X-axis position detection magnet Mh1 constituting a first position detection magnet is fixed on a front surface of the yoke 12 at a position facing the X-axis position detection Hall element H1 (see FIG. 7 to be described below) fixed to the circuit board 21 fixed to the movable member 2.

The X-axis position detection magnet Mh1 has an S-pole 1s and an N-pole 1n which are arranged with a space in the direction X, and the X-axis position detection Hall element H1 is disposed so as to face an intermediate position between the S-pole 1s and the N-pole 1n.

The N-pole 1n of the X-axis position detection magnet Mh1 is disposed on the left side in the direction X as viewed from the imaging optical system 101 side with respect to the S-pole 1s of the X-axis position detection magnet Mh1.

The Y-axis rotation position detection magnet Mh2 constituting a second position detection magnet is fixed on the

front surface of the yoke 12 at a position facing the Y-axis rotation position detection Hall element H2 (see FIG. 7 to be described below) fixed to the circuit board 21 fixed to the movable member 2.

The Y-axis rotation position detection magnet Mh2 has an S-pole 2s and an N-pole 2n arranged with a space in the direction Y, and the Y-axis rotation position detection Hall element H2 is disposed so as to face an intermediate position between the S-pole 2s and the N-pole 2n.

The N-pole 2n of the Y-axis rotation position detection magnet Mh2 is disposed on the upper side of the direction Y as viewed from the imaging optical system 101 side with respect to the S-pole 2s of the Y-axis rotation position detection magnet Mh2.

The Y-axis rotation position detection magnet Mh3 constituting a third position detection magnet is fixed on the front surface of the yoke 12 at a position facing the Y-axis rotation position detection Hall element H3 (see FIG. 7 to be described below) fixed to the circuit board 21 fixed to the movable member 2.

The Y-axis rotation position detection magnet Mh3 has an S-pole 3s and an N-pole 3n arranged with a space in the direction Y, and the Y-axis rotation position detection Hall element H3 is disposed so as to face an intermediate position between the S-pole 3s and the N-pole 3n.

The N-pole 3n of the Y-axis rotation position detection magnet Mh3 is disposed on the lower side of the direction Y as viewed from the imaging optical system 101 side with respect to the S-pole 3s of the Y-axis rotation position detection magnet Mh3.

In the example shown in FIG. 4, the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3 are coupled and integrated by a coupling member 13. Since the coupling member 13 is fixed to the yoke 12, the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3 are fixed to the first support member 1A.

As shown in FIG. 5, the yoke 12 is fixed to the base 10 by screws SC1 to SC4 inserted from screw holes formed on a surface opposite to the imaging optical system 101 side of the base 10 of the first support member 1A.

The screw SC1 and the screw SC2 are respectively screwed into two screw holes formed so as to be arranged in the direction Y at a portion extending along the direction Y of the plus-shaped yoke 12.

The screw SC3 and the screw SC4 are respectively screwed into two screw holes formed so as to be arranged in the direction X at a portion extending along the direction X of the plus-shaped yoke 12.

As shown in FIG. 4, three flat surfaces 15a, 15b, and 15c perpendicular to the direction Z are formed on the surface of the imaging optical system 101 side of the base 10. The positions of the flat surfaces 15a, 15b, and 15c in the direction Z are all the same, and these flat surfaces are all formed on the same flat surface.

On the surface on the imaging optical system 101 side of the base 10, a through-hole 11a for restricting the movement of the movable member 2 is formed on an upper side in the direction Y from the Y-axis rotation position detection magnet Mh3, and a through-hole 11b for restricting the movement of the movable member 2 is formed on a lower side in the direction Y from the Y-axis rotation position detection magnet Mh2, as viewed from the imaging optical system 101 side.

A hook **16a** extending in the direction X in which one end of the spring **24a** shown in FIG. 3 is locked, a hook **16b** extending in the up direction of the direction Y in which one end of the spring **24b** shown in FIG. 3 is locked, and a hook **16c** extending in the down direction of the direction Y in which one end of the spring **24c** shown in FIG. 3 is locked are formed at a peripheral portion of the base **10**.

FIG. 6 is a perspective view of the movable member **2** in the image shake correction device **3** shown in FIG. 3 as viewed from the imaging optical system **101** side.

FIG. 7 is a perspective view of the movable member **2** shown in FIG. 6 as viewed from the side opposite to the imaging optical system **101** side.

FIG. 8 is a plan view of the movable member **2** shown in FIG. 6 as viewed from the side opposite to the imaging optical system **101** side. In FIG. 8, in order to facilitate understanding of the configuration of the movable member **2**, the circuit board **21** fixed to the movable member **2** is indicated by a broken line, and flexible print substrates **25**, **26**, and **27** connected to the circuit board **21** are indicated by imaginary lines.

As shown in FIG. 8, the movable member **2** comprises a substantially C-shaped base **22** constituted a straight-line-shaped portion extending in the direction X, a straight-line-shaped portion extending in the direction Y from a right end portion of this portion in the direction X, and a straight-line-shaped portion extending to the left side in the direction X from a lower end portion of a portion extending in the direction Y as viewed from the imaging optical system **101** side.

As shown in FIGS. 6 and 7, the circuit board **21** on which the imager **20** is mounted is fixed to the base **22** with an adhesive at a portion facing a region surrounded by the three portions.

As shown in FIGS. 6 to 8, the X-axis rotation drive coil **C1** is formed at the base **22** at a position facing each of the X-axis rotation drive magnets **Mv1** and **mv1** shown in FIG. 4.

The X-axis rotation drive coil **C2** is formed at the base **22** at a position facing each of the X-axis rotation drive magnets **Mv2** and **mv2** shown in FIG. 4.

The Y-axis drive coil **C3** is formed at the base **22** at a position facing each of the Y-axis drive magnets **Mv3** and **mv3** shown in FIG. 4.

The X-axis rotation drive coil **C1** shown in FIGS. 6 to 8 and the X-axis rotation drive magnets **Mv1** and **mv1** shown in FIG. 4 constitute an X-axis drive voice coil motor (VCM).

The X-axis drive VCM moves the movable member **2** in the direction X by electromagnetic induction between the X-axis rotation drive coil **C1** and the X-axis rotation drive magnets **Mv1** and **mv1** by causing a control current to flow through the X-axis rotation drive coil **C1**.

The X-axis rotation drive coil **C2** shown in FIGS. 6 to 8 and the X-axis rotation drive magnets **Mv2** and **mv2** shown in FIG. 4 constitute a VCM. This VCM and the X-axis drive VCM constitute a rotation drive VCM.

The rotation drive VCM rotates the movable member **2** around the rotation axis R with the center P of the light receiving surface **20a** with a rotation center by an electromagnetic induction action between the X-axis rotation drive coil **C1** and the X-axis rotation drive magnets **Mv1** and **mv1** and an electromagnetic induction between the X-axis rotation drive coil **C2** and the X-axis rotation drive magnets **Mv2** and **mv2** by reversing the directions of the control currents flowing through the X-axis rotation drive coil **C1** and the X-axis rotation drive coil **C2** shown in FIGS. 6 to 8.

The Y-axis drive coil **C3** shown in FIGS. 6 to 8 and the Y-axis drive magnets **Mv3** and **mv3** shown in FIG. 4 constitute a Y-axis drive VCM.

The Y-axis drive VCM moves the movable member **2** in the direction Y by an electromagnetic induction between the Y-axis drive coil **C3** and the Y-axis drive magnets **Mv3** and **mv3** by causing the control current to flow through the Y-axis drive coil **C3**.

As shown in FIG. 7, the X-axis position detection Hall element **H1** is fixed at a position facing the intermediate position between the S-pole **1s** and the N-pole **1n** of the X-axis position detection magnet **Mh1** on a surface of the first support member **1A** side of the circuit board **21** fixed to the base **22** (hereinafter, referred to as a rear surface of the circuit board **21**).

The Y-axis rotation position detection Hall element **H2** is fixed at a position facing the intermediate position between the S-pole **2s** and the N-pole **2n** of the Y-axis rotation position detection magnet **Mh2** on the rear surface of the circuit board **21**.

The Y-axis rotation position detection Hall element **H3** is fixed at a position facing the intermediate position between the S-pole **3s** and the N-pole **3n** of the Y-axis rotation position detection magnet **Mh3** on the rear surface of the circuit board **21**.

The X-axis position detection Hall element **H1** outputs a signal corresponding to a magnetic field supplied from the X-axis position detection magnet **Mh1**, and the system controller **108** detects a position of the movable member **2** in the direction X by an output change of this signal.

The Y-axis rotation position detection Hall element **H2** outputs a signal corresponding to a magnetic field supplied from the Y-axis rotation position detection magnet **Mh2**, and the system controller **108** detects a position of the movable member **2** in the direction Y by an output change of this signal.

The Y-axis rotation position detection Hall element **H3** outputs a signal corresponding to a magnetic field supplied from the Y-axis rotation position detection magnet **Mh3**.

The system controller **108** detects, as a position of the movable member **2** in the direction  $\theta$ , a rotation angle of the movable member **2** around the rotation axis R due to the change of the output signal of the Y-axis rotation position detection Hall element **H3** and the change of the output signal of the Y-axis rotation position detection Hall element **H2**.

FIG. 9 is a diagram showing a state in which the rear surface of the circuit board **21** fixed to the base **22** of the movable member **2** shown in FIG. 7 is viewed in the direction Z.

In FIG. 9, the center P of the light receiving surface **20a** of the imager **20** that overlaps the rear surface of the circuit board **21** is shown. In FIG. 9 a straight line **L1** which passes through the center P and is parallel to the direction X, and the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3** are arranged on the straight line **L1**. A distance from the Y-axis rotation position detection Hall element **H2** to the center P and a distance from the Y-axis rotation position detection Hall element **H3** to the center P are the same.

As shown in FIG. 4, the Y-axis rotation position detection magnet **Mh2** facing the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection magnet **Mh3** facing the Y-axis rotation position detection Hall element **H3** are arranged such that magnetic poles are opposite to each other in the direction Y.

## 11

In a case where the movable member **2** rotates in the right direction of the direction  $\theta$  as viewed from the imaging optical system **101** side, the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3** move in opposite directions to each other in the direction **Y** by the same distance. Thus, the outputs of the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3** are changed in the same manner.

The output signal of the Y-axis rotation position detection Hall element **H2** output signal, the movement direction and the movement distance of the Y-axis rotation position detection Hall element **H2**, the output signal of the Y-axis rotation position detection Hall element **H3**, the movement direction and the movement distance of the Y-axis rotation position detection Hall element **H3**, and the rotation angle of the movable member **2** in the direction  $\theta$  are associated with each other in advance, and thus, it is possible to detect the rotation position of the movable member **2** in the direction  $\theta$  by the output signals of the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3**.

Meanwhile, in a case where the movable member **2** moves only in the direction **Y**, the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3** move in the same direction in the direction **Y** by the same distance.

Thus, the output signals of the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3** are changed in opposite directions.

Therefore, in a case where the outputs of the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3** are changed in opposite directions, it is possible to detect the position of the movable member **2** in the direction **Y** by viewing the output of the Y-axis rotation position detection Hall element **H2** or the Y-axis rotation position detection Hall element **H3**.

As shown in FIGS. **6** to **8**, a hook **23a** extending in the same direction (direction **X**) as the hook **16a** is formed at the base **22** at a position facing the hook **16a** (see FIG. **4**) of the support member **1**. The other end of the spring **24a** shown in FIG. **3** is locked to the hook **23a**.

The movable member **2** is biased toward the first support member **1A** by the spring **24a** locked to the hooks **16a** and **23a**.

As shown in FIGS. **6** and **8**, a hook **23b** extending in the same direction (up direction of the direction **Y**) as the hook **16b** is formed at the base **22** at a position facing the hook **16b** (see FIG. **4**) of the support member **1**. The other end of the spring **24b** shown in FIG. **3** is locked to the hook **23b**.

The movable member **2** is biased toward the first support member **1A** by the spring **24b** locked to the hooks **16b** and **23b**.

As shown in FIGS. **6** to **8**, a hook **23c** extending in the same direction (down direction of the direction **Y**) as the hook **16c** is formed at the base **22** at a position facing the hook **16c** (see FIG. **4**) of the support member **1**. The other end of the spring **24c** shown in FIG. **3** is locked to the hook **23c**.

The movable member **2** is biased toward the first support member **1A** by the spring **24c** locked to the hooks **16c** and **23c**.

The pair of the hook **16a** and the hook **23a**, the pair of the hook **16b** and the hook **23b**, and the pair of the hook **16c** and the hook **23c** are formed such that a center of gravity of the

## 12

movable member **2** is disposed inside a triangle formed by connecting these three pairs in plan view viewed in the direction **Z**.

As shown in FIGS. **7** and **8**, a recess portion **290a** that accommodates a rolling element (spherical ball) for causing the movable member **2** to be movable on a surface perpendicular to the direction **Z** at a position facing the flat surface **15a** of the first support member **1A** shown in FIG. **4** is formed at the base **22**. A bottom surface **29a** of the recess portion **290a** is a flat surface perpendicular to the direction **Z**.

A recess portion **290b** that accommodates a rolling element for causing the movable member **2** to be movable on the surface perpendicular to the direction **Z** at a position facing the flat surface **15b** of the first support member **1A** shown in FIG. **4** is formed at the base **22**. A bottom surface **29b** of the recess portion **290b** is a flat surface perpendicular to the direction **Z**.

A recess portion **290c** that accommodates a rolling element for causing the movable member **2** to be movable on the surface perpendicular to the direction **Z** is formed at the base **22** at a position facing the flat surface **15c** of the first support member **1A** shown in FIG. **4**. A bottom surface **29c** of the recess portion **290c** is a flat surface perpendicular to the direction **Z**.

The positions of the bottom surfaces **29a**, **29b**, and **29c** in the direction **Z** are all the same, and the bottom surfaces are all formed on the same flat surface.

The movable member **2** moves on the flat surface perpendicular to the direction **Z** by rolling the rolling elements disposed between the bottom surface **29a** of the movable member **2** and the flat surface **15a** of the first support member **1A**, between the bottom surface **29b** of the movable member **2** and the flat surface **15b** of the first support member **1A**, and between the bottom surface **29c** of the movable member **2** and the flat surface **15c** of the first support member **1A**.

As shown in FIG. **8**, an attachment portion **28A** is formed on the surface of the first support member **1A** side of the base **22**. As shown in FIG. **7**, a flat plate portion **280a** extending in the down direction of the direction **Y** at a position overlapping the circuit board **21** is fixed to the attachment portion **28A** with screws. An insertion member **28a** protruding in the direction **Z** toward the first support member **1A** side is formed at the flat plate portion **280a**.

As shown in FIG. **8**, an attachment portion **28B** is formed on the surface of the first support member **1A** side of the base **22**. As shown in FIG. **7**, a flat plate portion **280b** extending in the up direction of the direction **Y** at a position overlapping the circuit board **21** is fixed to the attachment portion **28B** with screws. An insertion member **28b** protruding in the direction **Z** toward the first support member **1A** side is formed at the flat plate portion **280b**.

The insertion member **28a** is inserted into the through-hole **11a** of the first support member **1A** shown in FIG. **4**. The insertion member **28b** is inserted into the through-hole **11b** of the first support member **1A** shown in FIG. **4**.

In a case where the movable member **2** moves on the surface perpendicular to the direction **Z**, the movement range of the insertion member **28a** is limited to the inside of the through-hole **11a**, and the movement range of the insertion member **28b** is limited to the inside of the through-hole **11b**. Thus, the movement range of the movable member **2** (the movement range in the direction **X**, the movement range in the direction **Y**, and the movement range in the direction  $\theta$ ) is restricted to a predetermined range by the pair

## 13

of the insertion member **28a** and the through-hole **11a** and the pair of the insertion member **28b** and the through-hole **11b**.

The pair of the insertion member **28a** and the through-hole **11a** constitutes a movement restrictor MR1 (see FIG. **12** to be described below) that restricts the movement range of the movable member **2**. The pair of the insertion member **28b** and the through-hole **11b** constitutes a movement restrictor MR2 (see FIG. **12** to be described below) that restricts the movement range of the movable member **2**.

As shown in FIG. **7**, a connector **21a** and a connector **21b** are formed at an upper end portion of the rear surface of the circuit board **21** fixed to the movable member **2** in the direction Y. A connector **21c** is formed at an end portion on a side close to the base **22** among the end portions on the rear surface of the circuit board **21** in the direction X.

The connector **21a** and the connector **21b** include terminals connected to various terminals (a power supply terminal which is a terminal for supplying a power, a ground terminal which is a terminal for grounding, a terminal for outputting a signal, and a drive terminal) of the imager **20** mounted on the circuit board **21**.

The flexible print substrate **26** which is a first flexible substrate including wirings connected to the terminals included in the connectors is connected to the connector **21a**.

The flexible print substrate **25** which is a first flexible substrate including wirings connected to the terminals included in the connectors is connected to the connector **21b**.

The connector **21c** includes terminals connected to output terminals of the X-axis position detection Hall element H1, the Y-axis rotation position detection Hall element H2, and the Y-axis rotation position detection Hall element H3 mounted on the rear surface of the circuit board **21**.

The flexible print substrate **27** which is a second flexible substrate including wirings connected to the terminals included in the connector is connected to the connector **21c**.

The flexible print substrate **27** includes a fixed portion **27a** that extends along the direction Y and is fixed to the base **22**, and a non-fixed portion **27b** that is free with respect to the base **22**.

A movable unit is constituted by the movable member **2** that includes the X-axis rotation drive coil C1, the X-axis rotation drive coil C2, and the Y-axis drive coil C3, the imager **20**, the circuit board **21** that includes the X-axis position detection Hall element H1, the Y-axis rotation position detection Hall element H2, and the Y-axis rotation position detection Hall element H3, and the flexible print substrates **25** to **27** connected to the circuit board **21**. The movable support device is constituted by the movable unit and the support member **1**.

FIG. **10** is a side view showing of the circuit board **21** fixed to the movable member **2** shown in FIG. **6** and the flexible print substrate connected to the circuit board as viewed in the direction X. In FIG. **10**, a part of the flexible print substrates is shown by a broken line in order to facilitate understanding.

As shown in FIGS. **10** and **7**, the flexible print substrate **25** includes a first portion **25a** (broken line portion) extending in the up direction of the direction Y from the connector **21b** and a folded portion **25b** (solid line portion) folded in the down direction of the direction Y at an end portion of the first portion **25a**.

Although not shown in FIG. **10**, the flexible print substrate **26** has the same configuration as that of the flexible print substrate **25**, and includes a first portion **26a** extending in the up direction of the direction Y from the connector **21a**

## 14

and a folded portion **26b** folded in the down direction of the direction Y at an end portion of the first portion **26a**, as shown in FIG. **7**.

As shown in FIGS. **10** and **7**, the flexible print substrate **27** includes a fixed portion **27a** which is fixed to the base **22**, and includes a second portion **270** (broken line portion) which extends in the down direction of the direction Y, and a folded portion **271** (solid line portion) folded in the up direction of the direction Y at an end portion of the second portion **270**.

The non-fixed portion **27b** shown in FIG. **7** is constituted by a portion excluding the fixed portion **27a** of the second portion **270** and the folded portion **271**.

A distal end of the folded portion **25b**, a distal end of the folded portion **26b**, and a distal end of the folded portion **271** are connected to a connector of a main substrate (a substrate on which the system controller **108** is formed) (not shown) in the digital camera **100**.

Next, details of the arrangement of the magnets fixed to the first support member **1A** shown in FIG. **4** will be described.

FIG. **11** is a front view of the first support member **1A** shown in FIG. **4** as viewed in the direction Z from the imaging optical system **101** side.

In the image shake correction device **3**, six magnets are fixed to the base **10** of the first support member **1A**, as shown in FIG. **11**. Thus, the arrangement of the magnets is devised such that the magnetic fields of these six magnets do not influence the magnetic fields of the other magnets.

Specifically, in a case where two adjacent magnets among all the magnets (the X-axis rotation drive magnet Mv1, the X-axis rotation drive magnet Mv2, the Y-axis drive magnet Mv3, the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3) fixed to the first support member **1A** are focused, the same poles of the two magnets face each other.

In a case where two magnets are adjacent to each other, in the front view of FIG. **11**, a length of the shortest line segment connecting the peripheral edges of the two magnets is short to the extent that the magnetic field of one of the two magnets influences the magnetic field of the other magnet.

In the example shown in FIG. **11**, the X-axis rotation drive magnet Mv1 and the Y-axis rotation position detection magnet Mh2 are adjacent to each other, and the N-pole **2n** of the X-axis rotation drive magnet Mv1 and the N-pole **2n** of the Y-axis rotation position detection magnet Mh2 face each other.

In the example shown in FIG. **11**, the X-axis position detection magnet Mh1 and the Y-axis rotation position detection magnet Mh3 are adjacent to each other, and the S-pole **1s** of the X-axis position detection magnet Mh1 and the S-pole **3s** of the Y-axis rotation position detection magnet Mh3 face each other.

In the example shown in FIG. **11**, the X-axis position detection magnet Mh1 and the Y-axis rotation position detection magnet Mh2 are adjacent to each other, and the N-pole **1n** of the X-axis position detection magnet Mh1 and the N-pole **2n** of the Y-axis rotation position detection magnet Mh2 face each other.

In the example shown in FIG. **11**, the Y-axis rotation position detection magnet Mh2 and the X-axis rotation drive magnet Mv2 are adjacent to each other, and the S-pole **2s** of the X-axis rotation driving of the Y-axis rotation position detection magnet Mh2 and the S-pole of the X-axis rotation drive magnet Mv2 face each other.



In the example shown in FIG. 11, the X-axis rotation drive magnet Mv2 and the Y-axis drive magnet Mv3 are adjacent to each other, and the S-pole of the X-axis rotation drive magnet Mv2 and the S-pole of the Y-axis drive magnet Mv3 are face each other.

The image shake correction device 3 detects the rotation position of the movable member 2 in the direction  $\theta$  by the two magnets of the Y-axis rotation position detection magnet Mh2 and the Y-axis rotation position detection magnet Mh3 and the Y-axis rotation position detection Hall element H2 and the Y-axis rotation position detection Hall element H3 facing the two magnets.

Thus, it is important to uniformize the detection accuracy of the Y-axis rotation position detection Hall element H2 and the Y-axis rotation position detection Hall element H3. The changes of the output signals of the Y-axis rotation position detection Hall element H2 and the Y-axis rotation position detection Hall element H3 in a case where the movable member 2 is rotated need to be equal.

Therefore, as shown in FIG. 11, the Y-axis rotation position detection magnet Mh2 and the Y-axis rotation position detection magnet Mh3 are arranged symmetrically with respect to a straight line L2 that passes through the center P of the light receiving surface 20a of the imager 20 and extends in the direction Y.

The N-pole 2n and the S-pole 2s of the Y-axis rotation position detection magnet Mh2 are arranged symmetrically with respect to a straight line L3 that passes through the center P of the light receiving surface 20a of the imager 20 and extends in the direction X. The N-pole 3n and the S-pole 3s of the Y-axis rotation position detection magnet Mh3 are arranged symmetrically with respect to the straight line L3.

Distances between the N-pole 2n and the S-pole 2s and the straight line L3 and distances between the N-pole 3n and the S-pole 3s and the straight line L3 are all the same.

In order to uniformize the influence of the magnetic field of the X-axis position detection magnet Mh1 on the magnetic field of the Y-axis rotation position detection magnet Mh2 and the magnetic field of the Y-axis rotation position detection magnet Mh3, the S-pole 1s and the N-pole 1n of the X-axis position detection magnet Mh1 are arranged symmetrically with respect to the straight line L2.

In order to prevent the magnetic field of the Y-axis drive magnet Mv3 from influencing the magnetic field of the X-axis position detection magnet Mh1, the X-axis position detection magnet Mh1 is disposed on the up direction side of the direction Y with respect to the straight line L3, and the Y-axis drive magnet Mv3 is disposed on the down direction side of the direction Y with respect to the straight line L3.

In order to reduce the influence of the magnetic fields of the X-axis rotation drive magnet Mv1 and the X-axis rotation drive magnet Mv2 on the magnetic field of the Y-axis rotation position detection magnet Mh2, the X-axis rotation drive magnet Mv1 and the X-axis rotation drive magnet Mv2 are arranged symmetrically with respect to the straight line L3.

In order to uniformize rotation drive forces in one direction and the other direction of the direction  $\theta$  of the movable member 2, the X-axis rotation drive magnet Mv1 and the X-axis rotation drive magnet Mv2 have the same configuration.

Meanwhile, in a case where the digital camera 100 is in the normal posture (the posture in which the direction Y and the gravity direction are parallel), the Y-axis drive magnet Mv3 having a plane area greater than each of the X-axis rotation drive magnet Mv1 and the X-axis rotation drive magnet Mv2 is used in order to obtain a sufficient drive force

for moving the movable member 2 against the gravity applied to the movable member 2.

The X-axis rotation drive magnet Mv1, the X-axis rotation drive magnet Mv2, and the Y-axis drive magnet Mv3 need a large magnetic force in order to move the movable member 2.

Thus, it is preferable that thicknesses of the X-axis rotation drive magnet Mv1, the X-axis rotation drive magnet Mv2, and the Y-axis drive magnet Mv3 are greater than thicknesses of the position detection magnets (the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3) of the movable member 2.

In the image shake correction device 3 having the aforementioned configuration, the drive magnets (the X-axis rotation drive magnet Mv1, the X-axis rotation drive magnet Mv2, and the Y-axis drive magnet Mv3) of the movable member 2 and the position detection magnets (the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3) of the movable member 2 are individually provided. Thus, the position detection accuracy of the movable member 2 can be improved.

In a case where two adjacent magnets among the six magnets fixed to the first support member 1A are focused, the same poles of the two magnets face each other. Thus, the same poles of the two adjacent magnets do not attract each other, and a decrease in the magnetic force of each of the two magnets can be prevented.

As described above, according to the image shake correction device 3, decreases in the magnetic forces of the drive magnets (the X-axis rotation drive magnet Mv1, the X-axis rotation drive magnet Mv2, and the Y-axis drive magnet Mv3) of the movable member 2 can be prevented.

It is possible to stabilize the magnetic fields applied to the X-axis rotation drive coil C1, the X-axis rotation drive coil C2, and the Y-axis drive coil C3, and it is possible to improve the drive performance of the movable member 2.

According to the image shake correction device 3, it is possible to prevent decreases of the magnetic forces of the position detection magnets (the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3) of the movable member 2.

Thus, it is possible to stabilize the magnetic fields applied to the X-axis position detection Hall element H1, the Y-axis rotation position detection Hall element H2, and the Y-axis rotation position detection Hall element H3, and it is possible to improve the position detection accuracy of the movable member 2.

In the image shake correction device 3, the movable member 2 is driven such that the position of the movable member 2 becomes a desired position. Thus, the improvement of the position detection accuracy of the movable member 2 is particularly important for improving the image shake correction performance.

In the image shake correction device 3, the Y-axis rotation position detection magnet Mh2 and the Y-axis rotation position detection magnet Mh3 are arranged symmetrically with respect to the straight line L2, and the Y-axis rotation position detection magnets Mh2 and Mh3 are arranged such that two magnetic poles are symmetrically with respect to the straight line L3.

Therefore, it is possible to uniformize the detection accuracy of the Y-axis rotation position detection Hall element H2 and the Y-axis rotation position detection Hall element H3, and it is possible to uniformize the changes of the output

signals of the Y-axis rotation position detection Hall element H2 and the Y-axis rotation position detection Hall element H3 in a case where the movable member 2 is rotated.

In the image shake correction device 3, the two magnetic poles of the X-axis position detection magnet Mh1 are arranged symmetrically with respect to the straight line L2. Thus, the influence of the magnetic field of the X-axis position detection magnet Mh1 on the magnetic field of the Y-axis rotation position detection magnet Mh2 and the magnetic field of the Y-axis rotation position detection magnet Mh3 can be uniformized.

Due to these effects, it is possible to improve the position detection accuracy (particularly the detection accuracy of the rotation position in the direction  $\theta$ ) of the movable member 2.

In the image shake correction device 3, the X-axis position detection magnet Mh1 is disposed on the up direction side in the direction Y with respect to the straight line L3, and the Y-axis drive magnet Mv3 is disposed on the down direction side in the direction Y with respect to the straight line L3.

Thus, it is possible to prevent the magnetic field of the Y-axis drive magnet Mv3 from influencing the magnetic field of the X-axis position detection magnet Mh1. As a result, the position detection accuracy of the movable member 2 can be improved.

In the image shake correction device 3, the X-axis rotation drive magnet Mv1 and the X-axis rotation drive magnet Mv2 are arranged symmetrically with respect to the straight line L3. Thus, it is possible to reduce the influence of the magnetic fields of the X-axis rotation drive magnet Mv1 and the X-axis rotation drive magnet Mv2 on the magnetic field of the Y-axis rotation position detection magnet Mh2. As a result, the position detection accuracy of the movable member 2 can be improved.

In the image shake correction device 3, the plane area of the Y-axis drive magnet Mv3 is greater than the plane areas of the X-axis rotation drive magnet Mv1 and the X-axis rotation drive magnet Mv2. Thus, in a state in which the digital camera 100 is in the normal posture, the drive force in the direction Y of the movable member 2 can be sufficiently secured.

The position detection magnets (the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3) of the movable member 2 of the image shake correction device 3 are arranged such that the S-poles and the N-poles are arranged with a space.

The S-poles and the N-poles of the X-axis position detection magnet Mh1, the Y-axis rotation position detection magnet Mh2, and the Y-axis rotation position detection magnet Mh3 may be integrated. However, the S-pole and the N-pole are separated, and thus, the position detection accuracy by the Hall elements can be improved. A range in which the position of the Hall element can be detected can be widened.

Although the image shake correction device 3 performs the image shake correction by moving the movable member 2 in three directions, that is, the direction X, the direction Y, and the direction  $\theta$ , it is possible to improve the position detection accuracy and the drive performance by arranging the same poles of the two adjacent magnets so as to face each other as described above even though the image shake correction is performed by moving the movable member 2 in two directions of the direction X and the direction Y.

For example, in a case where the image shake correction device 3 does not to move the movable member 2 in the

direction  $\theta$ , the pair of the Y-axis rotation position detection magnet Mh2 and the Y-axis rotation position detection Hall element H2 may be removed, and the pair of the X-axis rotation drive magnet Mv1 and the X-axis rotation drive coil C1 may be removed.

In this configuration, the X-axis rotation drive magnet Mv2 functions as the first drive magnet, the Y-axis rotation drive magnet Mv3 functions as the second drive magnet, the X-axis position detection magnet Mh1 functions as the first position detection magnet, and the Y-axis rotation position detection magnet Mh3 functions as the second position detection magnet.

Even in this configuration, the same poles of the two adjacent magnets are arranged to face each other, and thus, the influence of each magnet on the magnetic field of the other magnet is reduced. Accordingly, it is possible to improve the position detection accuracy and drive performance.

The image shake correction device 3 has a configuration in which the magnets are fixed to the first support member 1A and the drive coils and the position detectors facing the magnets are fixed to the movable member 2. However, the effects described above can be similarly obtained even in the configuration in which the magnets are fixed to the movable member 2, and the X-axis rotation drive coil C1, the X-axis rotation drive coil C2, the Y-axis drive coil C3, the X-axis position detection Hall element H1, the Y-axis rotation position detection Hall element H2, and the Y-axis rotation position detection Hall element H3 are fixed to the first support member 1A.

Although the image shake correction device 3 corrects image shake by moving the imager 20, the arrangement of the magnets is effective even in the device that corrects image shake by moving the lens included in the imaging optical system 101. Specifically, in the image shake correction device having the movable member to which the lens is fixed and the support member that supports the movable member to be movable, the arrangement of the plurality of drive magnets and the plurality of position detection magnets fixed to any of the movable member and the support member may be the arrangement in which the same poles of the two adjacent magnets face each other, as shown in FIG. 11.

As shown in FIGS. 7, 8, and 10, in the image shake correction device 3, the flexible print substrate 25 and the flexible print substrate 26 are drawn in the up direction of the direction Y and then is folded in the down direction of the direction Y after upward in the direction Y, and the flexible print substrate 27 is drawn in the down direction of the direction Y and then is folded in the up direction of the direction Y.

For example, the widths or thicknesses of the flexible print substrates 25 to 27 are adjusted such that the total of the elastic force applied to the movable member 2 from the flexible print substrate 25 and the flexible print substrate 26 toward the down direction of the direction Y and the gravity applied to the movable member 2 in a case where the digital camera 100 is in the normal posture is the same as the elastic force applied to the movable member 2 from the flexible print substrate 27 toward the up direction of the direction Y.

By doing this, in a case where the digital camera 100 is in the normal posture, the power for holding the movable member 2 at a position of a reference posture can be reduced.

In the image shake correction device 3, it is preferable that the flexible print substrate 25 and the flexible print substrate 26 include wirings connected to terminals other than the

power supply terminal and the ground terminal among the terminals of the imager **20** and the flexible print substrate **27** includes wirings (power supply line and ground line) connected to the power supply terminal and the ground terminal among the terminals of the imager **20**.

The flexible print substrate having a less thickness can have a lower elastic force. However, it is necessary to increase the widths of the power supply line and the ground line in order to reduce the thicknesses. Meanwhile, in a case where the width of the flexible print substrate is increased, the spring multiplier of the flexible print substrate is increased.

According to the aforementioned preferred configuration, the flexible print substrate **25** and the flexible print substrate **26** do not include the power supply line and the ground line, and thus, the widths of the flexible print substrate **25** and the flexible print substrate **26** are not increased. As a result, the flexible print substrate **25** and the flexible print substrate **26** are thinned, and thus, it is possible to reduce the elastic force of the flexible print substrate **25** and the flexible print substrate **26**.

As described above, the elastic force of the flexible print substrate **25** and the flexible print substrate **26** is reduced, and thus, the elastic force of the flexible print substrate **27** necessary for canceling the resultant force of the elastic force and the gravity can be reduced.

As a result, degrees of freedom in designing the flexible print substrates **25** to **27** are increased, and thus, the manufacturing cost of the image shake correction device **3** can be reduced.

According to the aforementioned preferred configuration, the elastic force by the flexible print substrates **25** to **27** can be reduced. Thus, the power required for driving the movable member **2** can be reduced, or the drive response of the movable member **2** can be improved.

According to the aforementioned preferable configuration, the flexible print substrates **25** and **26** do not include the power supply line and the ground line. Thus, it is possible to prevent power supply noise from being mixed into the imaging signals output via the flexible print substrates **25** and **26**, and it is possible to improve the quality of the captured image.

In a case where the flexible print substrate **27** includes the power supply line and the ground line, the thickness of the flexible print substrate **27** may be greater than the thickness of each of the flexible print substrate **25** and the flexible print substrate **26**.

As described above, the width of the flexible print substrate **27** can be prevented from being increased by increasing the thickness of the flexible print substrate **27** including the power supply line and the ground line, and the size of the image shake correction device **3** can be reduced.

Since the width of the flexible print substrate **27** is reduced and the spring multiplier can be reduced, it is possible to more easily design the flexible print substrate **27**.

It is preferable that the flexible print substrate **27** includes wirings connected to the X-axis rotation drive coil **C1**, the X-axis rotation drive coil **C2**, and the Y-axis drive coil **C3** in addition to the power supply line, the ground line, and the wirings connected to the X-axis rotation position detection Hall element **H1**, the Y-axis rotation position detection Hall element **H2**, and the Y-axis rotation position detection Hall element **H3**.

According to this configuration, the flexible print substrate **25** and the flexible print substrate **26** include only wirings of a signal processing system necessary for imaging,

and the flexible print substrate **27** includes only wiring necessary for driving the movable member **2**.

As described above, the wirings of the signal processing system and the wirings of the driving system are formed on different substrates, and thus, the quality of the captured image can be improved, and the drive performance of the movable member **2** can be improved.

The effects obtained by the preferred configurations of the flexible print substrates **25** to **27** can be similarly obtained even in the image shake correction device **3** that can move the movable member **2** only in the two directions of the direction **X** and the direction **Y**. In a case where the movable member **2** moves in three directions, since the movable member **2** becomes heavier, the configurations of the flexible print substrates **25** to **27** are particularly effective.

Next, the details of the two movement restrictors **MR1** and **MR2** provided in the image shake correction device **3** will be described.

FIG. **12** is a schematic diagram showing the first support member **1A** shown in FIG. **5** as viewed in the direction **Z** from the side opposite to the imaging optical system **101** side.

FIG. **12** is an enlarged view of a portion at which the through-holes **11a** and **11b** of the first support member **1A** are formed, and this portion is schematically shown by a rectangle. In FIG. **12**, the screws **SC1** to **SC4** shown in FIG. **5** are not shown.

FIG. **12** shows the Y-axis rotation position detection Hall elements **H2** and **H3** fixed to the movable member **2** located on the depth side of the paper surface and the insertion members **28a** and **28b** inserted into the through-holes **11a** and **11b** formed in the movable member **2**.

As shown in FIG. **12**, in the reference state, the center of the insertion member **28a** is located at the center of the through-hole **11a**, and the center of the insertion member **28b** is located at the center of the through-hole **11b**.

As shown in FIG. **12**, the through-hole **11a** of the movement restrictor **MR1** and the through-hole **11b** of the movement restrictor **MR2** are substantially square.

FIG. **13** is an enlarged view of the through-hole **11a** shown in FIG. **12**. A shape of the through-hole **11b** is the same as that of the through-hole **11a**.

As shown in FIG. **13**, the through-hole **11a** includes four sides **110**, **111**, **113**, and **114** having the same length, a curve **115** that connects the side **110** and the side **113**, a curve **116** that connects the side **113** and the side **111**, a curve **117** that connects the side **111** and the side **114**, and a curve **118** that connects the side **114** and the side **110**.

The sides **110** and **111** are parallel to the direction **X**. The sides **113** and **114** are parallel to the direction **Y**. A distance between the side **113** and the side **114** and a distance between the side **110** and the side **111** are the same.

The curves **115** to **118** are arcs of a circle using a center **110p** of the through-hole **11a** with a center.

Lengths of line segments of the curves **115** to **118** are sufficiently smaller than the lengths of the sides **110** to **114**. Specifically, the lengths of the line segments of the curves **115** to **118** are  $\frac{1}{10}$  or less of the lengths of the sides **110** to **114**.

As stated above, the through-hole **11a** (or the through-hole **11b**) becomes a substantial square by slightly rounding the four corners of the square, but may be a perfect square.

In FIG. **13**, a diagonal line of the square which is the shape of the through-hole **11a** (or the through-hole **11b**) is indicated by a one-dot chain line. This diagonal line is a portion overlapping the through-hole **11a** (or the through-hole **11b**) among straight lines connecting an intersection of an exten-

## 21

sion line of the side **110** and an extension line of the side **114** and an intersection of an extension line of the side **113** and an extension line of the side **111**.

As shown in FIG. **12**, in a state in which the insertion members **28a** and **28b** are present at the centers of the through-holes **11a** and **11b** (the aforementioned reference state), a diagonal line (second diagonal line) of the through-hole **11b** overlaps an extension line **L4** of the diagonal line (first diagonal line) of the through-hole **11a**. The center **P** of the light receiving surface **20a** overlaps a line connecting the diagonal line of the through-hole **11a** and the diagonal line of the through-hole **11b**.

As shown in FIG. **12**, a distance **Lx1** in the direction **X** between the movement restrictor **MR1** and the movement restrictor **MR2** is the same as a distance **Ly** in the direction **Y** between the movement restrictor **MR1** and the movement restrictor **MR2**.

The distance **Lx1** and the distance **Ly** are equal to or greater than 0.75 times and are equal to or less than 1.25 times of a distance **Lx2** in the direction **Y** between the Y-axis rotation position detection Hall element **H2** and the Y-axis rotation position detection Hall element **H3**.

The distance **Lx1** refers to a distance between the centers of the through-hole **11a** and the through-hole **11b**, or a distance between the centers of the insertion member **28a** and the insertion member **28b**. The distance **Ly** refers to the distance between the centers of the through-hole **11a** and the through-hole **11b**, or the distance between the centers of the insertion member **28a** and the insertion member **28b**.

As described above, in the image shake correction device **3**, the diagonal line of the through-hole **11b** overlaps the extension line **L4** of the diagonal line of the through-hole **11a**, and the center **P** of the light receiving surface **20a** overlaps the extension line **L4**. Thus, the insertion member **28a** moves along a circumference of a circle of which a line connecting the center **P** and the insertion member **28a** is used as a radius. Since this circle passes through the vicinity of the diagonal line of the through-hole **11a**, the movement amount of the insertion member **28a** can be maximized.

Similarly, since the insertion member **28b** moves along a circumference of a circle of which a line connecting the center **P** and the insertion member **28b** is used as a radius, the movement amount can be maximized. As a result, the rotatable amount of the movable member **2** can be maximized, and the image shake correction performance can be improved.

In the image shake correction device **3**, each of the distance **Lx1** and the distance **Ly** is equal to or greater than 0.75 times and is equal to or less than 1.25 times the distance **Lx2**. The distance **Lx1** and the distance **Ly** are each a first distance, and the distance **Lx2** is a second distance.

As stated above, the distance **Lx1**, the distance **Ly**, and the distance **Lx2** are close to each other, and thus, the movement amounts of the insertion members **28a** and **28b** in a case where the movable member **2** is rotated, and the movement amounts of the Y-axis rotation position detection Hall elements **H2** and **h3** with respective to the Y-axis rotation position detection magnets **Mh2** and **Mh3** can be close to each other. Accordingly, it is possible to increase the position detection accuracy of the movable member **2** in the direction  $\theta$ .

In the movement restrictors **MR1** and **MR2** shown in FIG. **12**, the same effects can be obtained even though the through-holes **11a** and **11b** are changed to the recess portions formed in the surface of the movable member **2** side of the base **10**.

## 22

The movement restrictor **MR1** may be configured such that the through-hole **11a** or the recess portion is formed in the flat plate portion **280a** of the movable member **2** and the insertion member **28a** inserted into the through-hole **11a** or the recess portion is formed at on the surface of the movable member **2** of the base **10** of the first support member **1A**.

Similarly, the movement restrictor **MR2** may be configured such that the through-hole **11b** or the recess portion formed in the flat plate portion **280b** of the movable member **2** and the insertion member **28b** inserted into the through-hole **11b** or the recess portion is formed on the surface of the movable member **2** side of the base **10** of the first support member **1A**.

In these configurations, the rotation amount of the movable member **2** can be maximized by adopting the planar shape of the through-hole or the recess portion and the arrangement of the two through-holes or recess portions as the configuration shown in FIG. **12**.

The planar shapes of the through-holes **11a** and **11b** of the movement restrictors **MR1** and **MR2** of the image shake correction device **3** are not square, and may be a rectangle as shown in FIG. **14**. That is, in a case where the planar shapes of the through-holes **11a** and **11b** are rectangular, the aforementioned arrangement is effective.

FIG. **14** is a diagram showing a modification example of the movement restrictors **MR1** and **MR2** shown in FIG. **12**. In the example shown in FIG. **14**, the planar shapes of the through-holes **11a** and **11b** of the movement restrictors **MR1** and **MR2** are rectangles including two sides parallel to the direction **X** and two sides parallel to the direction **Y**.

The diagonal line of the through-hole **11b** overlaps the extension line **L4** of the diagonal line of the through-hole **11a**, and the center **P** of the light receiving surface **20a** of the imager **20** overlaps the line connecting the diagonal line of the through-hole **11a** and the diagonal line of the through-hole **11b**.

Thus, in a case where the shapes of the through-holes **11a** and **11b** are rectangles, the rotation amount of the movable member **2** can be maximized by adopting the configuration shown in FIG. **14**. In FIG. **14**, the four corners of the planar shapes of the through-holes **11a** and **11b** may be rounded.

Next, a modification example of a configuration of each pair of the hooks **16a** to **16c** formed at the first support member **1A** of the image shake correction device **3** and the hooks **23a** to **23c** of the movable member **2** facing the hooks **16a** to **16c** will be described.

FIG. **15** is a diagram showing a modification example of the first support member **1A** shown in FIG. **11**.

The first support member **1A** shown in FIG. **15** has the same configuration as that of FIG. **11** except that the hook **16a** is changed to a hook **160a**, the hook **16b** is changed to a hook **160b**, and the hook **16c** is changed to a hook **160c**.

The hook **160a** has the same function as the hook **16a**, but the extending direction is changed. The hook **160b** has the same function as the hook **16b**, but the extending direction is changed. The hook **160c** has the same function as the hook **16c**, but the extending direction is changed.

FIG. **15** shows a first extension line **L5** which is an extension line of a line connecting a distal end and a base end (a boundary portion with the base **10**) of the hook **160a**, a second extension line **L6** which is an extension line of a line connecting a distal end and a base end (a boundary portion with the base **10**) of the hook **160b**, and a third extension line **L7** which is an extension line of a line connecting a distal end and a base end (a boundary portion with the base **10**) of the hook **160c**.

## 23

As shown in FIG. 15, the first extension line L5, the second extension line L6, and the third extension line L7 overlap the center P of the light receiving surface 20a of the imager 20.

FIG. 16 is a diagram showing a modification example of the movable member 2 shown in FIG. 8.

The movable member 2 shown in FIG. 16 has the same configuration as that of FIG. 8 except that the hook 23a is changed to a hook 230a, the hook 23b is changed to a hook 230b, and the hook 23c is changed to a hook 230c. FIG. 16 shows the first extension line L5, the second extension line L6, and the third extension line L7 shown in FIG. 15.

The hook 230a has the same function as the hook 23a, but the extending direction is changed. The hook 230b has the same function as the hook 23b, but the extending direction is changed. The hook 230c has the same function as the hook 23c, but the extending direction is changed.

The extending direction of the hook 230a matches the extending direction of the hook 160a shown in FIG. 15. The line connecting the distal end and the base end of the hook 230a and the center P overlaps the first extension line L5.

The extending direction of the hook 230b matches the extending direction of the hook 160b shown in FIG. 15. The line connecting the distal end and the base end of the hook 230b and the center P overlaps the second extension line L6.

The extending direction of the hook 230c matches the extending direction of the hook 160c shown in FIG. 15. The line connecting the distal end and the base end of the hook 230c and the center P overlaps the third extension line L7.

In the modification examples shown in FIGS. 15 and 16, the hook 160a constitutes a first support side locking portion, the hook 160b constitutes a second support side locking portion, and the hook 160c constitutes a third support side locking portion.

In the modification examples shown in FIGS. 15 and 16, the hook 230a constitutes a first movable side locking portion, the hook 230b constitutes a second movable side locking portion, and the hook 230c constitutes a third movable side locking portion.

The spring 24a shown in FIG. 3 that is locked to the hook 160a and the hook 230a constitutes a first elastic member. The spring 24b shown in FIG. 3 that is locked to the hook 160b and the hook 230b constitutes a second elastic member. The spring 24c shown in FIG. 3 that is locked to the hook 160c and the hook 230c constitutes a third elastic member.

According to the image shake correction device 3 including the hooks 160a to 160c and the hooks 230a to 230c of the modification example as shown in FIGS. 15 and 16, in a case where the movable member 2 is rotated around the rotation axis R, the elastic force of the spring 24a locked to the hook 160a and the hook 230a, the elastic force of the spring 24b locked to the hook 160b and the hook 230b, and the elastic force of the spring 24c locked to the hook 160c and the hook 230c are generated only in the rotation direction of the movable member 2.

Accordingly, the drive response in a case where the movable member 2 is rotationally driven can be improved by determining the distances of the springs 24a to 24c from the center P and the multiplier of the springs 24a to 24c such that the elastic forces of the springs 24a to 24c are equal for each spring in a case where the movable member 2 is rotated.

As described above, in a case where the movable member 2 is rotated, since it is not necessary to design the springs 24a to 24c with consideration for the elastic force in the rotation direction, it is possible to easily design the image shake correction device 3.

## 24

FIG. 17 is a diagram showing a modification example of the arrangement of the hooks 160a to 160c in the base 10 shown in FIG. 15. In FIG. 17, only the outer edge of the base 10 is shown.

In the example shown in FIG. 17, a case where the center P is present on the extension lines connecting the distal ends and the base ends of the hooks 160a to 160c is the same as that in FIG. 15, but the installation locations of the hooks 160a to 160c are different from those in FIG. 15.

In the example shown in FIG. 17, the hooks 160a to 160c are formed on the base 10 such that the figure connecting the portions of the hooks 160a to 160c to which the springs are locked forms an equilateral triangle TR. The center P of the light receiving surface 20a overlaps the center of the equilateral triangle TR.

The hooks 230a to 230c of the movable member 2 are formed on the base 22 in the same direction as the hooks 160a to 160c at positions of vertices of the equilateral triangle TR.

As described above, the hooks 160a to 160c and the hooks 230a to 230c are arranged so as to overlap the vertices of the equilateral triangle TR, and thus, the distances between the springs 24a to 24c and the center P can be uniformized. As a result, it is possible to more easily design the springs 24a to 24c.

The resultant force of the elastic forces applied to the movable member 2 from the springs 24a to 24c in a case where the movable member 2 moves in the direction X or the direction Y can be made zero, and the drive response of the movable member 2 in the direction X and the direction Y can be improved.

Although it has been described in FIGS. 15 to 17 that there are three pairs of the hooks formed on the first support member 1A and the hooks formed on the movable member 2 facing the hooks, four or more pairs may be used.

FIG. 18 is a view showing another modification example of the first support member 1A shown in FIG. 11. In FIG. 18, only the outer edge of the base 10 is shown.

The first support member 1A shown in FIG. 18 has the same configuration of FIG. 11 except that the hook 16a is changed to the hook 160a, the hook 16b is changed to the hook 160b, the hook 16c is changed to the hook 160c, and a hook 160d is further added.

Although not shown, a hook having the same shape as the hook 160a extending in the same direction as the hook 160a is formed at the base 22 of the movable member 2a at a position facing the hook 160a.

A hook having the same shape as the hook 160b extending in the same direction as the hook 160b is formed at the base 22 of the movable member 2 at a position facing the hook 160b.

A hook having the same shape as the hook 160c extending in the same direction as the hook 160c is formed at the base 22 of the movable member 2 at a position facing the hook 160c.

A hook having the same shape as the hook 160d extending in the same direction as the hook 160d is formed at the base 22 of the movable member 2 at a position facing the hook 160d.

Spring are locked to the hooks 160a to 160d and the hooks of the movable member 2 facing the hooks, and the movable member 2 is biased to the first support member 1A by these four springs.

In this modification example, the hook 160d constitutes a fourth support side locking portion. The hook of the movable member 2 facing the hook 160d constitutes a fourth movable side locking portion. The spring locked to the hook

## 25

**160d** and the hook of the movable member **2** facing this hook constitutes a fourth elastic member.

FIG. **18** shows the first extension line **L5** which is the extension line of the line connecting the distal end and the base end (the boundary portion with the base **10**) of the hook **160a**, the second extension line **L6** which is the extension line of the line connecting the distal end and the base end (the boundary portion with the base **10**) of the hook **160b**, the third extension line **L7** which is the extension line of the line connecting the distal end and the base end (the boundary portion with the base **10**) of the hook **160c**, and the fourth extension line **L8** which is the extension line of the line connecting the distal end and the base end (the boundary portion with the base **10**) of the hook **160d**.

As shown in FIG. **18**, the first extension line **L5**, the second extension line **L6**, the third extension line **L7**, and the fourth extension line **L8** overlap the center **P** of the light receiving surface **20a** of the imager **20**.

As stated above, the number of hook pairs is four, and thus, it is possible to urge the movable member **2** against the first support member **1A** with more stable force.

The first extension line **L5**, the second extension line **L6**, the third extension line **L7**, and the fourth extension line **L8** overlap the center **P**. With this configuration, when the movable member **2** is rotated, it is not necessary to design the spring with consideration for a spring force in the rotation direction. Thus, it is possible to easily design the image shake correction device **3**.

As shown in FIG. **18**, in a case where the image shake correction device **3** includes four hook pairs, it is possible to easily design the springs by providing the hooks **160a** to **160d** at the base **10** such that the figure connecting the portions to which the springs of the four pairs are locked forms a square. The drive response of the movable member **2** in the direction **X** and the direction **Y** can be improved.

The first extension line **L5**, the second extension line **L6**, the third extension line **L7**, and the fourth extension line **L8** shown in FIGS. **15** to **18** may overlap the center of gravity of the movable member **2**.

In the movable member **2**, the imager **20** and the circuit board **21** are heavy. Thus, the center of gravity of the movable member **2** and the center **P** of the light receiving surface **20a** are close in many cases.

In a case where there is a restriction on the direction of the hook in the design, it is possible to expect the same effects as in a case where the center **P** and the extension lines overlap by providing the hooks such that the centers of gravity and the extension lines overlap.

As shown in FIG. **7**, the image shake correction device **3** is configured such that the position detectors such as the X-axis position detection Hall element **H1**, the Y-axis rotation position detection Hall element **H2**, and the Y-axis rotation position detection Hall element **H3** are fixed to the rear surface of the circuit board **21**.

A large number of circuit elements constituting a circuit connected to the terminals of the imager **20** and a circuit connected to the terminals of the connectors **21a** to **21c** are formed on the rear surface of the circuit board **21**.

These circuit elements include capacitors, resistors, thermistors, or oscillators. Magnetic materials are included in plating that covers the terminals of these circuit elements or these circuit elements.

Hereinafter, a preferable example of the arrangement of the circuit element including the magnetic materials on the rear surface of the circuit board **21** will be described.

## 26

FIG. **19** is a schematic diagram showing a preferable configuration example of the rear surface of the circuit board **21** in the image shake correction device **3**.

FIG. **19** shows a state in which the circuit board **21** of the image shake correction device **3** is viewed in the direction **Z** from the rear surface side in the reference state. FIG. **19** shows the X-axis position detection magnet **Mh1**, the Y-axis rotation position detection magnet **Mh2**, and the Y-axis rotation position detection magnet **Mh3** that overlap the circuit board **21**.

As shown in FIG. **19**, a first region **ar1** (a region with diagonal lines) overlapping with the X-axis position detection magnet **Mh1**, a first region **ar2** (a region with diagonal lines) overlapping the Y-axis rotation position detection magnet **Mh2**, and a first region **ar3** (a region with diagonal lines) overlapping the Y-axis rotation position detection magnet **Mh3** are present on the rear surface of the circuit board **21**.

The first region **ar1** is a region overlapping the magnet that supplies the magnetic field to the X-axis position detection Hall element **H1**, and indicates the N-pole **1n**, the S-pole **1s**, and a region in which a region between the N-pole **1n** and the S-pole **1s** overlaps the circuit board **21**.

The first region **ar2** is a region overlapping the magnet that supplies the magnetic field to the Y-axis rotation position detection Hall element **H2**, and indicates the N-pole **2n**, the S-pole **2s**, and a region in which a region between the N-pole **2n** and the S-pole **2s** overlaps the circuit board **21**.

The first region **ar3** is a region overlapping with the magnet that supplies the magnetic field to the Y-axis rotation position detection Hall element **H3**, and indicates the N-pole **3n**, the S-pole **3s**, and a region in which a region between the N-pole **3n** and the S-pole **3s** overlaps the circuit board **21**.

On the rear surface of the circuit board **21**, a frame-shaped second region **AR1** surrounding the first region **ar1** is present around the first region **ar1**, a frame-shaped second region **AR2** surrounding the first region **ar2** is present around the first region **ar2**, and a frame-shaped second region **AR3** surrounding the first region **ar3** is present around the first region **ar3**.

In the second region **AR2** and the second region **AR3**, a high-density region **210b** in which circuit elements are arranged is formed with a density higher than a density of circuit elements arranged in the regions excluding the second regions **AR1** to **AR3** on the rear surface of the circuit board **21**.

The high-density region **210b** formed in the second region **AR2** is disposed so as to be adjacent to an upper end portion of the first region **ar2** in the direction **Y**.

The high-density region **210b** formed in the second region **AR3** is disposed so as to be adjacent to an upper end portion of the first region **ar3** in the direction **Y**.

In the configuration example shown in FIG. **19**, on the rear surface of the circuit board **21**, the high-density region **210b** in which many circuit elements are arranged than the other regions is present so as to be adjacent to the directions **Y** of the first regions **ar2** and **ar3**. Thus, an attractive force can be generated between a large amount of magnetic materials included in the circuit elements formed in the high-density region **210b** and the Y-axis rotation position detection magnets **Mh2** and **Mh3**.

In a state in which the digital camera **100** is in the normal posture, the movable member **2** tends to move in the down direction of the direction **Y** in FIG. **19** due to gravity. However, the movable member **2** can be moved in the up direction of the direction **Y** due to this attractive force.

Therefore, the attractive force between the high-density region **210b** and the magnet is adjusted by adjusting the amount of magnetic materials in the high-density region **210b** or the distance from the high-density region **210b** to the first regions **ar2** to **ar3**, and thus, the movement of the movable member **2** due to gravity in the normal posture can be reduced. Accordingly, it is possible to reduce a power required to return the movable member **2** to the reference position.

FIG. **20** is a diagram showing a first modification example of the circuit board **21** shown in FIG. **19**.

The circuit board **21** shown in FIG. **20** has the same configuration as that shown in FIG. **19** except that three high-density regions **210b** are added to the second region **AR1** and three high-density regions **210b** are added to each of the second region **AR2** and the second region **AR3**.

As shown in FIG. **20**, in the second region **AR1**, the high-density region **210b** is disposed so as to be adjacent to the end portion of the first region **ar1** on the down direction side of the direction **Y**, and the high-density region **210b** is disposed so as to be adjacent to both end portions of the first region **ar1** in the direction **X**.

In the second region **AR2**, the high-density region **210b** is disposed so as to be adjacent to both end portions of the first region **ar2** in the direction **Y**, and the high-density region **210b** is disposed so as to be adjacent to both end portions of the first region **ar2** in the direction **X**.

In the second region **AR3**, the high-density region **210b** is disposed so as to be adjacent to both end portions of the first region **ar3** in the direction **Y**, and the high-density region **210b** is disposed so as to be adjacent to both end portions of the first region **ar3** in the direction **X**.

According to the modification example shown in FIG. **20**, the attractive force between the high-density region **210b** on a lower side of each of the first regions **ar1** to **ar3** and the magnet and the attractive force between the high-density region **210b** on an upper side of each of the first regions **ar2** to **ar3** and the magnet are adjusted, and thus, the movable member **2** can be held at the reference position without driving the movable member **2** in a case where the digital camera **100** is in the normal posture.

According to the modification example shown in FIG. **20**, the attractive force between the high-density region **210b** on a left side of each of the first regions **ar1** to **ar3** and the magnet and the attractive force between the high-density region **210b** on a right side of each of the first regions **ar1** to **ar3** and the magnet are adjusted, and thus, the movable member **2** can be held at the reference position without driving the movable member **2** even though the digital camera **100** is in a rotation posture (a posture in which the direction **X** is parallel to the gravity) which is rotated by 90 degrees from the normal posture.

Thus, the power required for driving the movable member **2** can be reduced in both the normal posture and the rotational posture.

The second region **AR1** shown in FIGS. **19** and **20** is a range in which the magnetic force of the X-axis position detection magnet **Mh1** sufficiently reaches, and is, for example, a range to a position separated from the end portion of the first region **ar1** in the direction **X** and the direction **Y** by about 1 mm to 5 mm.

Similarly, the second region **AR2** is a range in which the magnetic force of the Y-axis rotation position detection magnet **Mh2** sufficiently reaches, and is, for example, a range separated from the end portion of the first region **ar2** in the direction **X** and the direction **Y** by about 1 mm to 5 mm.

Similarly, the second region **AR3** is a range in which the magnetic force of the Y-axis rotation position detection magnet **Mh3** sufficiently reaches, and is, for example, a range separated from the end portion of the first region **ar3** in the direction **X** and the direction **Y** by about 1 mm to 5 mm.

In the modification example shown in FIGS. **19** and **20**, the attractive force between the magnetic materials and the magnet in the high-density region **210b** also functions as an urging force that urges the movable member **2** against the first support member **1A**.

Thus, the spring **24a**, the spring **24b**, and the spring **24c** shown in FIG. **3** may be removed by adjusting the attractive force. Accordingly, it is possible to reduce the size and cost of the image shake correction device **3**.

FIG. **21** is a diagram showing a second modification example of the circuit board **21** shown in FIG. **19**.

The circuit board **21** shown in FIG. **21** has the same configuration as the circuit board **21** shown in FIG. **19** except that non-arrangement regions **AR6**, **AR7**, and **AR8** which are regions in which circuit elements are not arranged are formed around each of the first regions **ar1** to **ar3**, the X-axis position detection Hall element **H1**, the Y-axis rotation position detection Hall element **H2**, and the Y-axis rotation position detection Hall element **H3**.

The non-arrangement region **AR6** is a square using the X-axis position detection Hall element **H1** as a center, and is a region where a square having two sides parallel to the direction **X** and two sides parallel to the direction **Y** and the first region **ar1** overlap.

A length from the center of the X-axis position detection Hall element **H1** to an end portion of the non-arrangement region **AR6** in the direction **X** is a value which is equal to or greater than 1.5 times of the maximum movement distance with which the movable member **2** can be moved in one direction of the direction **X**.

A length from the center of the X-axis position detection Hall element **H1** to an end portion of the non-arrangement region **AR6** in the direction **Y** is a value which is equal to or greater than 1.5 times of the maximum movement distance with which the movable member **2** can be moved in one direction of the direction **Y**.

The length from the center of the X-axis position detection Hall element **H1** to the end portion of the non-arrangement region **AR6** in the direction **X** and the length from the center of the X-axis position detection Hall element **H1** to the end portion of the non-arrangement region **AR6** in the direction **Y** may be values which are equal to or greater than the distance between the X-axis position detection Hall element **H1** and the X-axis position detection magnet **Mh1**.

The non-arrangement region **AR7** is a square using the Y-axis rotation position detection Hall element **H2** as a center, and is a region in which a square having two sides parallel to the direction **X** and two sides parallel to the direction **Y** and the first region **ar2** overlap.

A length from the center of the Y-axis rotation position detection Hall element **H2** to an end portion of the non-arrangement region **AR7** in the direction **X** is a value which is equal to or greater than 1.5 times of the maximum movement distance with which the movable member **2** can be moved in one direction of the direction **X**.

A length from the center of the Y-axis rotation position detection Hall element **H2** to an end portion of the non-arrangement region **AR7** in the direction **Y** is a value which is equal to or greater than 1.5 times of the maximum movement distance with which the movable member **2** can be moved in one direction of the direction **Y**.

The length from the center of the Y-axis rotation position detection Hall element H2 to the end portion of the non-arrangement region AR7 in the direction X and the length from the center of the Y-axis rotation position detection Hall element H2 and the end portion of the non-arrangement region AR7 in the direction Y may be values which are equal to or greater than the distance between the Y-axis rotation position detection Hall element H2 and the Y-axis rotation position detection magnet Mh2.

The non-arrangement region AR8 is a square using the Y-axis rotation position detection Hall element H3 as a center, and is a region in which a square having two sides parallel to the direction X and two sides parallel to the direction Y and the first region ar3 overlap.

A length from the center of the Y-axis rotation position detection Hall element H3 to an end portion of the non-arrangement region AR8 in the direction X is a value which is equal to or greater than 1.5 times of the maximum movement distance with which the movable member 2 can be moved in one direction of the direction X.

A length from the center of the Y-axis rotation position detection Hall element H3 to an end portion of the non-arrangement region AR8 in the direction Y is a value which is equal to or greater than 1.5 times of the maximum movement distance with which the movable member 2 can be moved in one direction of the direction Y.

The length from the center of the Y-axis rotation position detection Hall element H3 to the end portion the non-arrangement region AR8 in the direction X of and the length from the center of the Y-axis rotation position detection Hall element H3 and the end portion of the non-arrangement region AR8 in the direction Y may be values which are equal to or greater than the distance between the Y-axis rotation position detection Hall element H3 and the Y-axis rotation position detection magnet Mh3.

According to the modification example shown in FIG. 21, since a region in which the circuit element including the magnetic materials is not disposed is formed around each of the X-axis position detection Hall element H1, the Y-axis rotation position detection Hall element H2, and the Y-axis rotation position detection Hall element H3, it is possible to stabilize the linearity of the output of each Hall element, and it is possible to perform highly accurate position detection.

The modification example shown in FIG. 21 is also applicable to the circuit board 21 shown in FIG. 20.

In the circuit board 21 shown in FIG. 21, the circuit elements may be arranged with a density lower than a density of the high-density region 210b at a portion of the first region ar1 excluding the non-arrangement region AR6, a portion of the first region ar2 excluding the non-arrangement region AR7, and a portion of the first region ar3 excluding the non-arrangement region AR8. However, the circuit elements are not arranged at these portions, and thus, it is possible to further improve the position detection accuracy.

The same effects obtained by the configuration of the circuit board 21 shown in FIGS. 19 to 21 are obtained even in the image shake correction device 3 in which the movable member 2 can be moved only in the two directions of the direction X and the direction Y. In a case where the movable member 2 is moved in three directions, the movable member 2 becomes heavier. Thus, the configuration of the circuit board 21 shown in FIGS. 19 to 21 is particularly effective.

As long as the position can be detected by a change of the magnetic field supplied from the magnet, a magnetic sensor other than the Hall element may be used as the position

detector for detecting the position of the movable member 2 in the image shake correction device 3.

Next, a configuration of a smartphone will be described as another embodiment of the imaging device of the present invention.

FIG. 22 shows an appearance of a smartphone 200 that is an embodiment of the imaging device of the present invention.

A smartphone 200 shown in FIG. 22 includes a flat plate casing 201, and comprises a display input unit 204 in which a display panel 202 as a display surface and an operation panel 203 as an input unit are integrated on one surface of the casing 201.

Such a casing 201 comprises a speaker 205, a microphone 206, an operation unit 207, and a camera unit 208. The configuration of the casing 201 is not limited thereto, and for example, a configuration in which the display surface and the input unit are independent can be employed, or a configuration having a folding structure or a slide mechanism can be employed.

FIG. 23 is a block diagram showing a configuration of the smartphone 200 shown in FIG. 22.

As shown in FIG. 23, the smartphone includes, as main components, a wireless communication unit 210, the display input unit 204, a call handling unit 211, the operation unit 207, the camera unit 208, a storage unit 212, an external input and output unit 213, a Global Positioning System (GPS) reception unit 214, a motion sensor unit 215, a power supply unit 216, and a main controller 220.

The smartphone 200 has, as a main function, a wireless communication function of performing mobile wireless communication through a base station apparatus BS (not shown) and a mobile communication network NW (not shown).

The wireless communication unit 210 performs wireless communication with the base station apparatus BS belonging to the mobile communication network NW according to an instruction of the main controller 220. The transmission and reception of various file data such as voice data, image data, and e-mail data, and reception of Web data or streaming data are performed by using this wireless communication.

Under the control of the main controller 220, the display input unit 204 displays images (still images and moving images) or text information, and visually transmits the images and information to the user, and is a so-called touch panel that detects a user operation for the displayed information. The display input unit comprises the display panel 202 and the operation panel 203.

The display panel 202 uses, as a display device, a liquid crystal display (LCD) or an organic electro-luminescence display (OLED).

The operation panel 203 is a device that is mounted so as to visually recognize the image displayed on the display surface of the display panel 202, and detects one or a plurality of coordinates operated by a finger of the user or a stylus. In a case where this device is operated by the finger of the user or the stylus, a detection signal generated due to the operation is output to the main controller 220. Subsequently, the main controller 220 detects an operation position (coordinates) on the display panel 202 based on the received detection signal.

As shown in FIG. 23, although it has been described that the display panel 202 and the operation panel 203 of the smartphone 200 illustrated as the embodiment of the imaging device of the present invention are integrally formed and



constitute the display input unit **204**, the operation panel **203** is disposed so as to completely cover the display panel **202**.

In a case where such an arrangement is adopted, the operation panel **203** may have a function of detecting the user operation even in a region outside the display panel **202**. In other words, the operation panel **203** may have a detection region (hereinafter, referred to as a display region) for an overlapped portion which overlaps with the display panel **202** and a detection region (hereinafter, referred to as a non-display region) for an outer edge portion which does not overlap with the display panel **202**.

The size of the display region and the size of the display panel **202** may completely match each other, and it is not necessary to match both the sizes. The operation panel **203** may have the outer edge portion and two sensitive regions which are inner portions other than the outer edge. A width of the outer edge portion is appropriately designed according to the size of the casing **201**.

Examples of the position detection method employed in the operation panel **203** include a matrix switch method, a resistive film method, a surface acoustic wave method, an infrared method, an electromagnetic induction method, and an electrostatic capacitance method.

The call handling unit **211** comprises the speaker **205** or the microphone **206**, converts the voice of the user input through the microphone **206** into voice data capable of being processed by the main controller **220** to output the voice data to the main controller **220** or decodes the voice data received by the wireless communication unit **210** or the external input and output unit **213** to output the decoded voice data from the speaker **205**.

For example, as shown in FIG. **22**, the speaker **205** may be mounted on the same surface as the surface on which the display input unit **204** is provided, and the microphone **206** may be mounted on a side surface of the casing **201**.

The operation unit **207** is a hardware key using a key switch, and receives an instruction from the user. For example, as shown in FIG. **22**, the operation unit **207** is a push button type switch which is mounted on a side surface of the casing **201** of the smartphone **200**, and is turned on by being pressed with the finger and is turned off by a restoring force such as a spring in a case where the finger is released.

The storage unit **212** stores a control program and control data of the main controller **220**, application software, address data associated with a name or a telephone number of a communication partner, the transmitted and received e-mail data, Web data downloaded by Web browsing, and download content data, and temporarily stores streaming data. The storage unit **212** includes an internal storage unit **217** built in the smartphone, and an external storage unit **218** having a slot for a detachable external memory.

The internal storage unit **217** and the external storage unit **218** constituting the storage unit **212** is realized by using a storage medium such as a memory (for example, MicroSD (registered trademark) memory) of a flash memory type, a hard disk type, a multimedia card micro type, or a card type, a random access memory (RAM), or a read only memory (ROM).

The external input and output unit **213** serves as an interface with all external devices coupled to the smartphone **200**, and directly or indirectly communicates with other external devices by (for example, universal serial bus (USB) or IEEE 1394) or a network (for example, Internet, wireless LAN, Bluetooth (registered trademark), radio frequency identification (RFID), Infrared Data Association (IrDA) (registered trademark), ultra wideband (UWB) (registered trademark), or ZigBee (registered trademark)).

Examples of the external device to be connected to the smartphone **200** includes a wired or wireless headset, an external wired or wireless charger, a wired or wireless data port, a memory card to be connected through a card socket, subscriber identity module (SIM)/user identity module (UIM) card, or an external audio and video device to be connected through an audio and video input and output (I/O) terminal, an external audio and video device to be connected in a wireless manner, a smartphone to be connected in a wired or wireless manner, a personal computer to be connected in a wired or wireless manner, or an earphone to be connected in a wired or wireless manner.

The external input and output unit **213** can transfer data transmitted from the external devices to the components in the smartphone **200** or can transmit data in the smartphone **200** to the external devices.

The GPS receiving unit **214** receives GPS signals transmitted from GPS satellites ST1 to STn according to an instruction of the main controller **220**, performs positioning calculation processing based on a plurality of received GPS signals, and detects the position of the smartphone **200** having latitude, longitude, and altitude. In a case where positional information can be acquired from the wireless communication unit **210** or the external input and output unit **213** (for example, a wireless LAN), the GPS receiving unit **214** can detect the position by using the positional information.

For example, the motion sensor unit **215** comprises a three-axis acceleration sensor, and detects physical motion of the smartphone **200** according to an instruction of the main controller **220**. The movement direction or acceleration of the smartphone **200** is detected by detecting the physical motion of the smartphone **200**. The detection result is output to the main controller **220**.

The power supply unit **216** supplies power stored in a battery (not shown) to the respective units of the smartphone **200** according to an instruction of the main controller **220**.

The main controller **220** comprises a microprocessor, operates according to the control program or control data stored in the storage unit **212**, and integrally controls the units of the smartphone **200**. The main controller **220** has a mobile communication control function of controlling the units of a communication system in order to perform voice communication or data communication through the wireless communication unit **210**, and an application processing function.

The application processing function is realized by the main controller **220** operating according to application software stored in the storage unit **212**. The application processing function is, for example, an infrared communication function of controlling the external input and output unit **213** to perform data communication with a device facing the smartphone, an electronic mail function of transmitting and receiving electronic mails, or a Web browsing function of browsing Web pages.

The main controller **220** has an image processing function of displaying video on the display input unit **204** based on image data (still image or moving image data), such as received data or downloaded streaming data.

The image processing function refers to a function of the main controller **220** decoding the image data, performing image processing on the decoding result, and displaying an image on the display input unit **204**.

The main controller **220** performs display control on the display panel **202** and operation detection control for detecting a user operation through the operation unit **207** and the operation panel **203**.

Through the performing of the display control, the main controller **220** displays an icon for activating application software or a software key, such as a scroll bar, or displays a window for creating electronic mails.

The scroll bar refers to a software key for receiving an instruction to move a display portion of an image which is too large to fit into the display region of the display panel **202**.

Through the performing of the operation detection control, the main controller **220** detects the user operation through the operation unit **207**, receives an operation on the icon or an input of a character string in an input field of the window through the operation panel **203**, or receives a scroll request of a display image through the scroll bar.

Through the performing of the operation detection control, the main controller **220** has a touch panel control function of determining whether or not an operation position on the operation panel **203** is the superimposed portion (display region) overlapping the display panel **202** or the outer edge portion (non-display region) not overlapping the display panel **202** other than the display region, and controlling the sensitive region of the operation panel **203** or the display position of the software key.

The main controller **220** may detect a gesture operation on the operation panel **203** and may execute a function set in advance according to the detected gesture operation.

The gesture operation is not a conventional simple touch operation, but means an operation to render a track with a finger, an operation to simultaneously designate a plurality of positions, or an operation to render a track for at least one of a plurality of positions by combining the aforementioned operations.

The camera unit **208** includes components other than the motion detection sensor **106**, the system controller **108**, and the image processing unit **107** of the digital camera **100** shown in FIG. 1. In the smartphone **200**, the main controller **220** controls the image shake correction device **3** based on information from the motion sensor unit **215** corresponding to the motion detection sensor **106** to perform image shake correction.

Captured image data generated by the camera unit **208** can be recorded in the storage unit **212** or can be output through the external input and output unit **213** or the wireless communication unit **210**.

Although it has been described in the smartphone **200** shown in FIG. 22 that the camera unit **208** is mounted on the same surface as the display input unit **204**, the mounting position of the camera unit **208** is not limited thereto, and the camera unit may be mounted on the rear surface of the display input unit **204**.

The camera unit **208** can be used for various functions of the smartphone **200**. For example, an image acquired by the camera unit **208** can be displayed on the display panel **202**, or an image in the camera unit **208** can be used as one operation input of the operation panel **203**.

In a case where the GPS receiving unit **214** detects the position, the position may be detected by referring to an image from the camera unit **208**. The optical axis direction of the camera unit **208** of the smartphone **200** can be determined or a current usage environment may be determined by referring to an image from the camera unit **208** without using the three-axis acceleration sensor or in combination with the three-axis acceleration sensor. An image from the camera unit **208** may be used in application software.

Image data of a still image or a moving image may be attached with positional information acquired by the GPS

receiving unit **214**, voice information (which may be converted to text information through voice-text conversion by the main controller) acquired by the microphone **206**, or posture information acquired by the motion sensor unit **215** and can be recorded in the storage unit **212**, or may be output through the external input and output unit **213** or the wireless communication unit **210**.

In the smartphone **200** having the aforementioned configuration, the image shake correction device **3** has the aforementioned configuration, and thus, it is possible to obtain various effects.

As described above, the following items are disclosed in this specification.

(1) There is provided an image shake correction device comprising a movable member, an imager that is fixed to the movable member, a support member that supports the movable member to be movable in a direction along a circumferential direction of a circle using a center of a light receiving surface of the imager as a center, and two movement restrictors that restrict a movement range of the movable member. Each of the two movement restrictors includes a recess portion or a through-hole formed in one of the movable member and the support member, and an insertion member formed in the other one of the movable member and the support member and inserted into the recess portion or the through-hole, a shape of the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface is a rectangle having two sides parallel to a longitudinal direction of the light receiving surface and two sides parallel to a short direction of the light receiving surface, and in a state in which the insertion members are present in centers of the two recess portions or through-holes, a second diagonal line of a second one of the two rectangles overlaps an extension line of a first diagonal line of a first one of the two rectangles, and the center of the light receiving surface overlaps a line connecting the first diagonal line and the second diagonal line.

(2) The image shake correction device according to (1), the shape of the recess portion or the through-hole is a square.

(3) The image shake correction device according to (1) or (2) further comprises a circuit board that has the imager mounted thereon, and is fixed to the movable member, and two position detectors that are arranged in the longitudinal direction on a rear surface opposite to a surface on which the imager is mounted of the circuit board to detect a position of the movable member in the direction along the circumferential direction. A line connecting the two position detectors overlaps the center of the light receiving surface of the imager as viewed in the direction perpendicular to the light receiving surface, a first distance between the two movement restrictors in the longitudinal direction is the same as a second distance between the two movement restrictors in the short direction, and each of the first distance and the second distance is equal to or greater than 0.75 times and is equal to or less than 1.25 times a distance between the two position detectors.

(4) There is provided an imaging device comprising the image shake correction device according to any one of (1) to (3).

The present invention is highly convenient and effective by being applied to a digital camera such as a single-lens reflex camera or a mirrorless camera, an in-vehicle camera, a surveillance camera, or a smartphone.

Although the present invention has been described in conjunction with the specific embodiments, the present

invention is not limited to these embodiments, and can be variously changed without departing from the technical idea of the disclosed invention.

## EXPLANATION OF REFERENCES

**100**: digital camera  
**101**: imaging optical system  
**20**: imager  
**3**: image shake correction device  
**104**: AFE  
**105**: imager drive unit  
**106**: motion detection sensor  
**108**: system controller  
**107**: image processing unit  
**K**: optical axis  
**1**: support member  
**1A**: first support member  
**Mh1**: X-axis position detection magnet  
**Mh2**: Y-axis rotation position detection magnet  
**Mh3**: Y-axis rotation position detection magnet  
**1s, 2s, 3s**: S-pole  
**1n, 2n, 3n**: N-pole  
**Mv1**: X-axis rotation drive magnet  
**Mv2**: X-axis rotation drive magnet  
**Mv3**: Y-axis drive magnet  
**1B**: second support member  
**mv1**: X-axis rotation drive magnet  
**mv2**: X-axis rotation drive magnet  
**mv3**: Y-axis drive magnet  
**2**: movable member  
**C1**: X-axis rotation drive coil  
**C2**: X-axis rotation drive coil  
**C3**: Y-axis drive coil  
**21**: circuit board  
**H1**: X-axis position detection Hall element  
**H2**: Y-axis rotation position detection Hall element  
**H3**: Y-axis rotation position detection Hall element  
**20a**: light receiving surface  
**P**: center of light receiving surface  
**R**: rotation axis  
**10**: base  
**11a, 11b**: through-hole  
**12, 14**: yoke  
**13**: coupling member  
**15a, 15b, 15c**: flat surface  
**16a, 16b, 16c**: hook  
**17a, 17b, 17c**: projecting portion  
**18**: yoke  
**19a**: hole portion  
**19b, 19c**: notch portion  
**SC1, SC2, SC3, SC4**: screw  
**21a, 21b, 21c**: connector  
**22**: base  
**23a, 23b, 23c**: hook  
**24a, 24b, 24c**: spring  
**25, 26, 27**: flexible print substrate  
**25a, 26a**: first portion  
**270**: second portion  
**25b, 26b, 271**: folded portion  
**27a**: fixed portion  
**27b**: non-fixed portion  
**28A, 28A**: attachment portion  
**28a, 28b**: insertion member  
**280a, 280b**: flat plate portion  
**29a, 29b, 29c**: bottom surface  
**290a, 290b, 290c**: recess portion

**MR1, MR2**: Movement Restrictor  
**L1, L2, L3**: straight line  
**L4**: extension line  
**110, 111, 113, 114**: side  
**115, 116, 117, 118**: curve  
**110p**: center of through-hole  
**L5**: first extension line  
**L6**: second extension line  
**L7**: third extension line  
**L8**: fourth extension line  
**160a, 160b, 160c, 160d**: hook  
**230a, 230b, 230c**: hook  
**TR**: equilateral triangle  
**ar1, ar2, ar3**: first region  
**AR1, AR2, AR3**: second region  
**21b**: high-density region  
**AR6, AR7, AR8**: non-arrangement region  
**200**: smartphone  
**201**: casing  
**202**: display panel  
**203**: operation panel  
**204**: display input unit  
**205**: speaker  
**206**: microphone  
**207**: operation unit  
**208**: camera unit  
**210**: wireless communication unit  
**211**: call handling unit  
**212**: storage unit  
**213**: external input and output unit  
**214**: GPS receiving unit  
**215**: motion sensor unit  
**216**: power supply unit  
**217**: internal storage unit  
**218**: external storage unit  
**220**: main controller  
**ST1 to STn**: GPS satellites

What is claimed is:

1. An image shake correction device comprising:
  - a movable member;
  - an imager that is fixed to the movable member;
  - a support member that supports the movable member to be movable; and
  - two movement restrictors that restrict a movement range of the movable member,
 wherein each of the two movement restrictors includes a recess portion or a through-hole formed in one of the movable member and the support member, and an insertion member formed in other one of the movable member and the support member and inserted into the recess portion or the through-hole, and
- in a state in which the insertion member is present at a center of each of the two recess portions or through-holes, a single virtual straight line extending through both of the two recess portions or through-holes overlaps a center of a light receiving surface of the imager.
2. The image shake correction device according to claim 1,
- wherein a shape of the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager is a rectangle.
3. The image shake correction device according to claim 1,
- wherein the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager includes four sides and four curves that connect the four sides respectively.

37

4. The image shake correction device according to claim 1, further comprising:  
 a first flexible substrate that includes wirings and is connected to a first side of the movable member,  
 a second flexible substrate that includes wirings and is connected to the first side of the movable member, and  
 a third flexible substrate that includes wirings and is connected to a second side of the movable member.
5. An image shake correction device comprising:  
 a movable member;  
 an imager that is fixed to the movable member;  
 a support member that supports the movable member to be movable; and  
 two movement restrictors that restrict a movement range of the movable member,  
 wherein each of the two movement restrictors includes a recess portion or a through-hole formed in one of the movable member and the support member, and an insertion member formed in other one of the movable member and the support member and inserted into the recess portion or the through-hole, and  
 in a state in which the insertion member is present at a center of each of the two recess portions or through-holes, a line connecting the centers of the two recess portions or through-holes overlaps a center of a light receiving surface of the imager.
6. The image shake correction device according to claim 5,  
 wherein a shape of the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager is a rectangle.
7. The image shake correction device according to claim 5,  
 wherein the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager includes four sides and four curves that connect the four sides respectively.
8. The image shake correction device according to claim 5, further comprising:  
 a first flexible substrate that includes wirings and is connected to a first side of the movable member,  
 a second flexible substrate that includes wirings and is connected to the first side of the movable member, and  
 a third flexible substrate that includes wirings and is connected to a second side of the movable member.
9. An image shake correction device comprising:  
 a movable member;  
 an imager that is fixed to the movable member;  
 a support member that supports the movable member to be movable; and  
 two movement restrictors that restrict a movement range of the movable member,  
 wherein each of the two movement restrictors includes a recess portion or a through-hole formed in one of the movable member and the support member, and an insertion member formed in other one of the movable member and the support member and inserted into the recess portion or the through-hole, and  
 in a state in which the insertion member is present at a center of each of the two recess portions or through-holes, a line connecting the two recess portions or through-holes overlaps a center of a light receiving surface of the imager.
10. The image shake correction device according to claim 9,

38

- wherein a shape of the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager is a rectangle.
11. The image shake correction device according to claim 9,  
 wherein the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager includes four sides and four curves that connect the four sides respectively.
12. The image shake correction device according to claim 9, further comprising:  
 a first flexible substrate that includes wirings and is connected to a first side of the movable member,  
 a second flexible substrate that includes wirings and is connected to the first side of the movable member, and  
 a third flexible substrate that includes wirings and is connected to a second side of the movable member.
13. An image shake correction device comprising:  
 a movable member;  
 an imager that is fixed to the movable member;  
 a support member that supports the movable member to be movable; and  
 two movement restrictors that restrict a movement range of the movable member,  
 wherein each of the two movement restrictors includes a recess portion or a through-hole formed in one of the movable member and the support member, and an insertion member formed in other one of the movable member and the support member and inserted into the recess portion or the through-hole, and  
 in a state in which the insertion member is present at a center of each of the two recess portions or through-holes, a single virtual straight line extending diagonally through both of the two recess portions or through-holes substantially overlaps a center of a light receiving surface of the imager.
14. The image shake correction device according to claim 13,  
 wherein a shape of the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager is a rectangle.
15. The image shake correction device according to claim 13,  
 wherein the recess portion or the through-hole as viewed in a direction perpendicular to the light receiving surface of the imager includes four sides and four curves that connect the four sides respectively.
16. The image shake correction device according to claim 13, further comprising:  
 a first flexible substrate that includes wirings and is connected to a first side of the movable member,  
 a second flexible substrate that includes wirings and is connected to the first side of the movable member, and  
 a third flexible substrate that includes wirings and is connected to a second side of the movable member.
17. An imaging device comprising the image shake correction device according to claim 1.
18. An imaging device comprising the image shake correction device according to claim 5.
19. An imaging device comprising the image shake correction device according to claim 9.
20. An imaging device comprising the image shake correction device according to claim 13.